
CHART
of the
ATLANTIC
OCEAN.
WEST
FLORIDA
GEORGIA
GULF of MEXICO
Bay of Honduras
SOUTH SEA

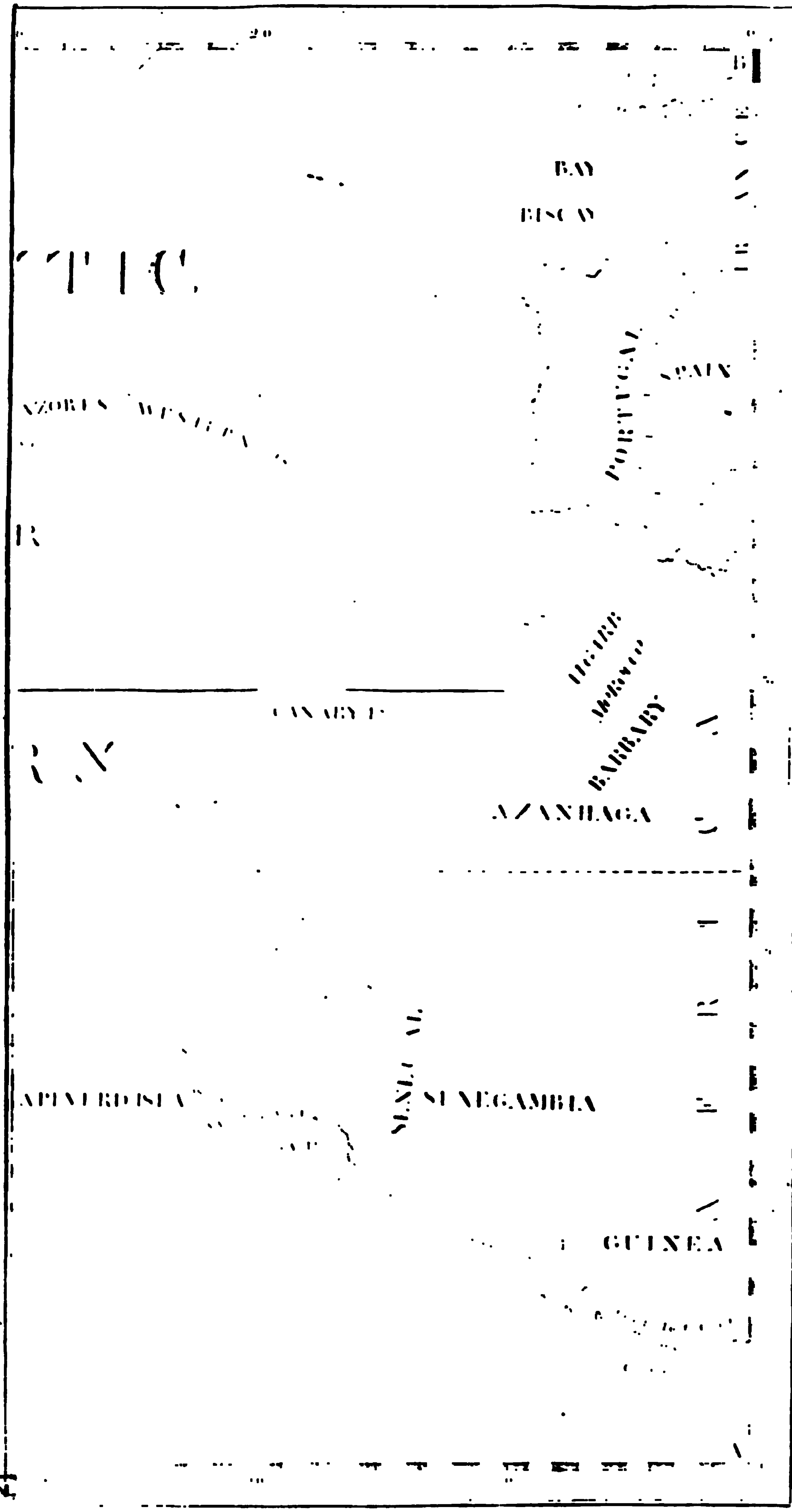
BAY
PORTUGAL
BARBARY
SENEGAMBIA
GUINEA

TABLE XLVII. contains the times of high water on the full and change of the moon, with the vertical rise of the tide, at many ports, harbours, &c. in the world. This table (like the preceding) depending wholly on observations, is therefore liable to be erroneous, though great pains have been taken to make it as correct as possible.

Most of the tables of this collection have been republished in London in several editions of a work having the following title: " *The Improved Practical Navigator, originally written and calculated by* NATHANIEL BOWDITCH; *revised, recalculated, and newly arranged, by* THOMAS KIRBY." But a number of mistakes have been made in printing the Tables of Mr. Kirby's first edition, some of which have been taken notice of by Dr. Mackay, in the preface of his " Complete Navigator;" and as the manner in which those mistakes are mentioned might lead the reader to suppose that the same errors existed in the American Tables, it is thought proper explicitly to state, that *not one* of the " many errors and contradictions," Doctor Mackay has mentioned, is to be found therein.

CONTENTS.

ADVERTISEMENT.

The Proprietor of BOWDITCH'S PRACTICAL NAVIGATOR, having expended a large sum in stereotyping most of the Tables in this Edition (fifth) hands it to a liberal public more correct than any work of the kind extant. The uncommon expense will, he hopes, be a suitable apology for soliciting patronage for such of his Nautical works as are entitled to merit, more particularly enumerated on the back of the title-page, to which they are referred by,

Respectfully,

Their Obt. Serv't,

EDMUND M. BLUNT.

Aug. 1821.

DIRECTIONS FOR THE BINDER,

PLATE	I.	TO FRONT THE TITLE PAGE.
———	II.	TO FRONT PAGE 20.
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SUBTRACTION OF DECIMALS.

Subtraction of decimals is performed in the same manner as in whole numbers, by observing to set the figures of the same denomination and the separating points directly under each other.

EXAMPLES.

From	81.467	80.75	1.254	1364.2
Take	2.63	.026	.316	25.163
Diff.	78.837	80.724	.938	1339.037

MULTIPLICATION OF DECIMALS.

Multiply the numbers together the same as if they were whole numbers, and point off as many decimals from the right hand as there are decimals in both factors together, and when it happens that there are not so many figures in the product as there must be decimals, then prefix as many ciphers to the left hand as will supply the defect.

EXAMPLE I.
Multiply 3.25 by 4.5

```
   3.25
   4.5
  -----
   1625
  1300
  -----
Answer 14.625
```

In one of the factors is one decimal and in the other two, their sum 3 is the number of decimals of the product.

EXAMPLE II.
Multiply 0.5 by 0.7

```
  0.5
  0.7
  ---
  0.35 Answer
```

EXAMPLE III.
Multiply 3.25 by .05

```
  3.25
   .05
  ----
  .1625 Product.
```

EXAMPLE IV. Multiply .17 by .06

```
       .17
       .06
       ----
Answer .0102
```

In each of the factors are two decimals, the product ought therefore to contain 4, and there being only three figures in the product I prefix a cipher.

EXAMPLE V. Multiply .18 by 24.

```
       .18
       24
       ---
       72
      36
      ---
Answer 4.32
```

EXAMPLE VI. Multiply 36.1 by 2.5

```
       36.1
       2.5
       -----
       18.05
       72.2
       -----
Answer 90.25
```

DIVISION OF DECIMALS.

Division of decimals is performed in the same manner as in whole numbers; only observing that the number of decimals in the quotient must be equal to the excess of the number of decimals of the dividend above those of the divisor.—When the divisor contains more decimals than the dividend, ciphers must be affixed to the right hand of the latter to make the number equal or exceed that of the divisor.

EXAMPLE I.
Divide 14.625 by 3.25

```
3.25)14.625(4.5
     1300
     ----
      1625
      1625
```

In this example there are 2 decimals in the divisor, and 3 in the dividend, hence there is one decimal in the quotient.

EXAMPLE II.
Divide 0.35 by 0.7

```
.7)0.35(.5
    35
```

EXAMPLE III.
Divide 2.1 by [illegible]

Previous to the division I affix a number of ciphers to the right hand of 2.1, which does not alter its value.

[illegible]

Therefore the answer is [illegible].

EXAMPLE IV.

Divide 9.6 by .06

.06)9.60

160 Answer.

Here by affixing a cipher to 9.6 it becomes 9.60, and has then 2 decimals in it, which is the same number as is in the divisor, therefore the quotient is an integer number.

EXAMPLE V.

Divide 17.256 by 1.16

```
1.16)17.25600(14.876
     116
     ---
      565
      464
      ---
      1016
       928
      ----
        880
        812
        ---
         680
         580
         ---
         100
```

REDUCTION OF DECIMALS.

If you wish to reduce a vulgar fraction to a decimal, you may add any number of ciphers to the numerator, and divide it by the denominator, the quotient will be the decimal fraction; the decimal point must be so placed that there may be as many figures to the right hand of it as you added ciphers to the numerator; if there are not as many figures in the quotient, you must place ciphers to the left hand to make up the number.

EXAMPLE I. Reduce $\frac{1}{5}$ to a decimal.

5)1.0

.2 Answer.

EXAMPLE II. Reduce $\frac{3}{8}$ to a decimal.

8)3.000

.375 Answer.

EXAMPLE III. Reduce 3 inches to the decimal of a foot.

Since 12 inches=1 foot, this fraction is $\frac{3}{12}$.

12)3.00

.25 Answer.

EXAMPLE IV. Reduce $3\frac{1}{2}$ inches to the decimal of a foot.

$3\frac{1}{2}=\frac{7}{2}$: this divided by 12 is $\frac{7}{24}$.

```
24)7.000(.291 Answer.
   48
   ---
   220
   216
   ---
     40
     24
     --
     16
```

EXAMPLE V. Reduce 1 foot and 6 inches to the decimal of a yard.

Here 1 foot 6 inches=18 inches.

And 1 yard=36 inches, therefore this fraction is $\frac{18}{36}$.

```
36)18.0(.5 Answer.
   180
```

If you have any decimal fraction, it is easy to find its value in the lower denominations of the same quantity; thus if the fraction was the decimal of a yard, by multiplying it by 3 we have its value in feet and parts; if we multiply this by 12, the product is its value in inches and parts; and in the same manner the values may be obtained in other cases.

EXAMPLE VI.

Required the value of 3.25 yards.

```
3.25
   3
----
 .75
  12
----
9.00
```

Answer 3 yards, 0 feet, 9 inches.

EXAMPLE VII.

Required the value of 7.231 days.

```
 7.231
    24
------
  924
 462
------
 5.544
    60
------
32.640
    60
------
38.400
```

Answer 7 days, 5 hours, 32 minutes, and 38 seconds.

GEOMETRY.

GEOMETRY is the Science which treats of the description, properties' and relations of magnitudes in general, of which there are three kinds or species, viz. a line which has only length without either breadth or thickness, a superficies, comprehended by length and breadth, and a solid, which has length, breadth, and thickness.

I.

A POINT considered mathematically has no length, breadth, or thickness.

II.

A STRAIGHT LINE or RIGHT LINE is the shortest distance between the two points which limits its length, as A———C

III.

A PLANE SUPERFICIES is that in which any two points being taken, the straight line between them lies wholly in that surface.

IV.

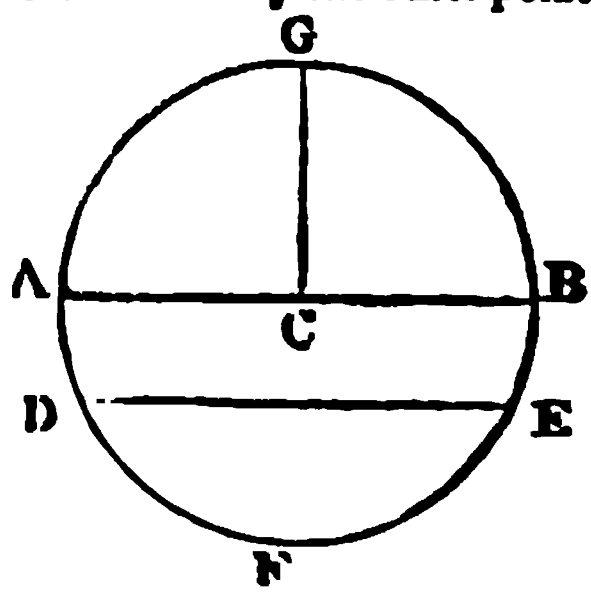
PARALLEL LINES are such as are in the same plane and which extended infinitely do never meet, as AB, DC.

A———B
D———C

V.

A CIRCLE is a plane figure, bounded by an uniform curve line; it is commonly described with a pair of compasses; one point of which is fixed, whilst the other is turned round to the place where the motion first began; the fixed point is called the CENTRE, and the line described by the other point is called the CIRCUMFERENCE.

VI.



The RADIUS of a circle, or SEMIDIAMETER, is a right line drawn from the centre to the circumference, as AC; or it is that line which is taken between the points of the compasses to describe the circle.

A DIAMETER of a circle is a right line drawn through the centre and terminated at both ends by the circumference, as ACB, and is the double of the radius AC. A diameter divides the circle, and its circumference into two equal parts.

VII.

An ARCH of a circle is any part or portion of the circumference, as DFE.

VIII.

The CHORD of an arch is a straight line joining the ends of the arch: it divides the circle into two unequal parts, called SEGMENTS, and is a chord to them both, as DE is the chord of the arches DFE and DGE.

IX.

A SEMICIRCLE, or half circle, is a figure contained under a diameter and the arch terminated by that diameter, as AGB or AFB. Any part of a circle contained between two radii and an arch, is called a SECTOR.

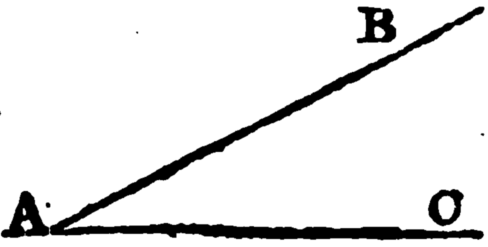
X.

A QUADRANT is half a semicircle, or one fourth part of a whole circle, as the figure CAG.

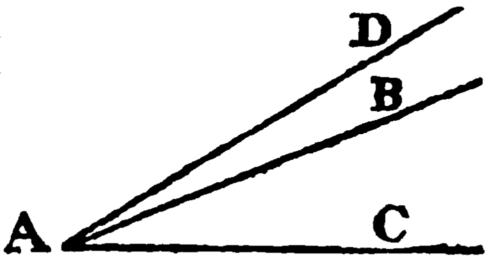
NOTE. All circles, whether great or small, are supposed to have their circumference divided into 360 equal parts, called degrees, and each degree into [illegible] called minutes, and each minute into 60 equal parts, called [illegible] [illegible] [illegible] as [illegible] the circumference [illegible]

XI.

An Angle is the inclination of two lines which meet, but not in the same direction.

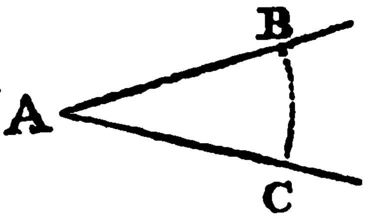


An angle is usually expressed by the letter placed at the angular point, as the angle A. But when two or more angles are at the same point, it is then necessary to express each by three letters, and the letter at the angular point is placed between the two. Thus, the angle formed by the lines AB, AC, is called the angle BAC or CAB, and that formed by AB, AD, is called the angle BAD, or DAB.



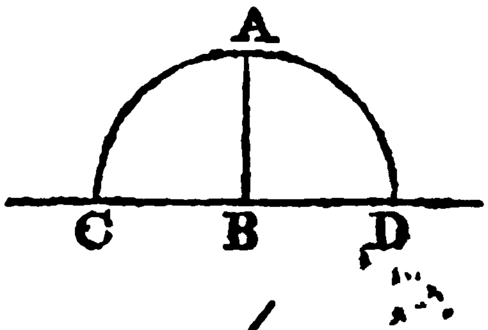
An angle is measured by the arch of a circle comprehended between the two legs that form the angle, the centre of the circle being the angular point.

Thus the angle A is measured by the arch BC described round the point A as a centre, and the angle is said to be of as many degrees as the arch is, that is, if the arch BC is 30°, then the angle BAC, is said to be an angle of 30 degrees.



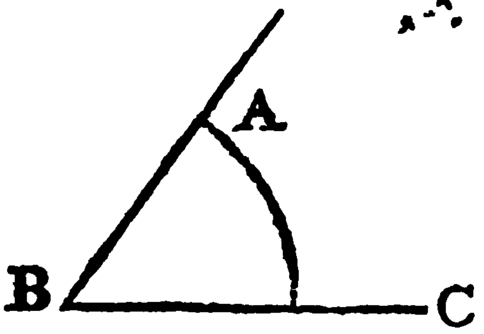
XII.

If a right line AB, fall upon another DC, so as to incline neither to the one side nor the other, but makes the angles ABC, ABD, equal to each other; then the line AB is said to be *perpendicular* to the line DC, and each of these angles is called a *right angle*, being each equal to a quadrant or 90°; because the sum of the two angles ABC, ABD, is measured by the semicircle DAC, described on the diameter DBC, and centre B.



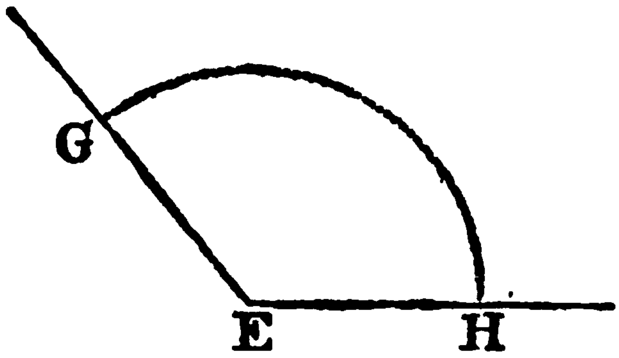
XIII.

An Acute Angle is less than a right angle, as ABC.



XIV.

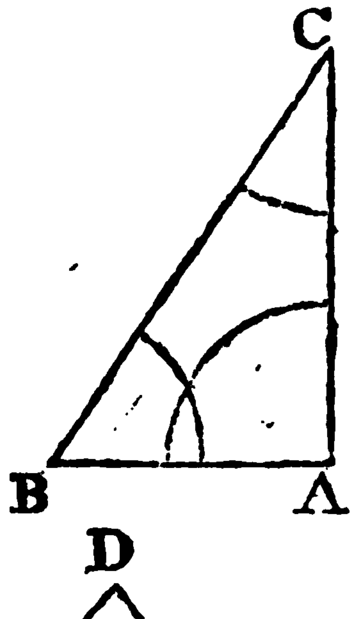
An Obtuse Angle is greater than a right angle, as GEH.



The least number of right lines that can include a space, are three which form a figure called a *Triangle*, consisting of six parts, viz. three sides and three angles: it is distinguished into three sorts, viz. a right angled triangle, an obtuse-angled triangle, and an acute angled triangle.

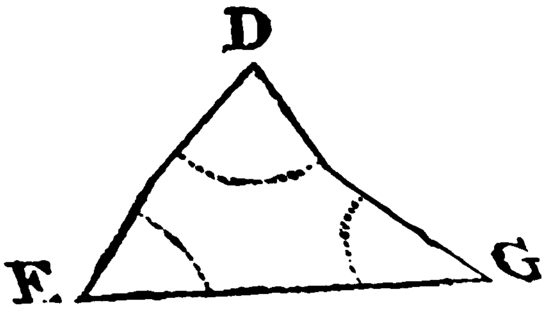
XV.

A Right-angled Triangle has one of its angles right; the side opposite the right angle is called the *hypotenuse*; and the other two sides are called legs; that which stands upright, is called the *perpendicular*, and the other the *base*; thus BC is the hypotenuse, AC the perpendicular, and AB the base; the angles opposite the two legs are both acute.



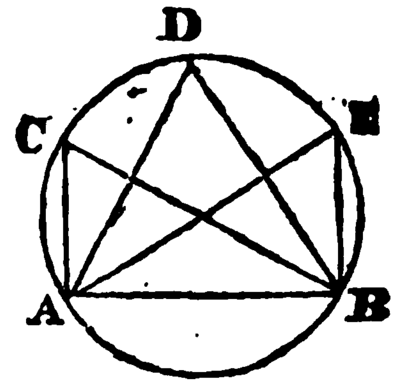
XVI.

An Acute-angled Triangle has each of its angles acute, as DEG.



XLI.

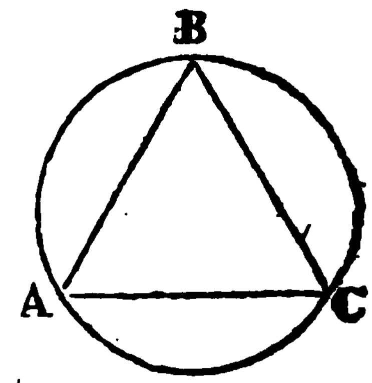
An angle at the circumference is measured by half the arch it subtends.



For an angle at the centre standing on the same arch is measured by the whole arch (*by art.* 11); but since an angle at the centre is double that at the circumference, (*art.* 40), it is evident that an angle at the circumference must be measured by half the arch it stands upon. *Hence all angles* ACB, ADB, AEB, &c. *at the circumference of a circle standing on the same chord* AB *are equal to each other*: for they are all measured by the same arch, viz. half the arch AB.

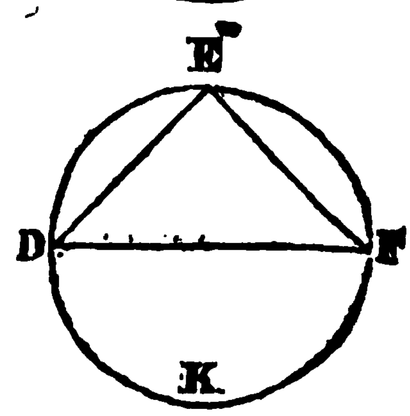
XLII.

An angle in a segment greater than a semicircle is less than a right angle.



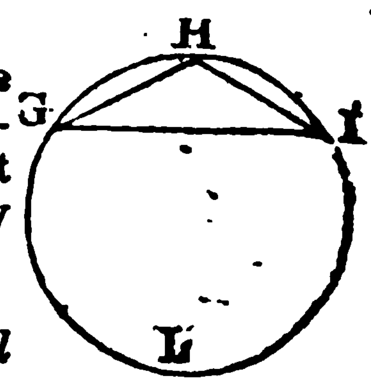
Thus if ABC be a segment greater than a semicircle, the arch AC on which it stands must be less than a semicircle and the half of it less than a quadrant or a right angle: but the angle ABC in the segment is measured by the half of the arch AC; therefore it is less than a right angle.

An angle in a semicircle is a right angle.



For since DEF is a semicircle, the arch DKF must also be a semicircle: but the angle DEF is measured by half the arch DKF, that is, by half a semicircle or by a quadrant; therefore the angle DEF is a right one.

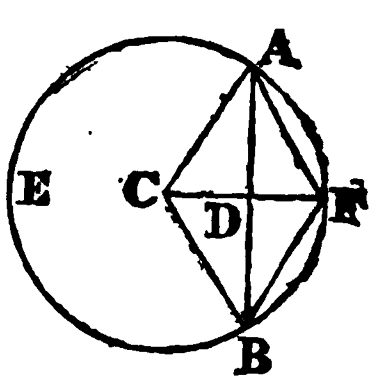
An angle in a segment less than a semicircle is greater than a right angle.



Thus if GHI be a segment less than a semicircle, the arch GLI on which it stands must be greater than a semicircle, and its half greater than a quadrant or right angle: therefore the angle GHI which is measured by half the arch GLI is greater than a right angle.

XLIII.

If from the centre C of the circle ABE, there be let fall the perpendicular CD on the chord AB; it will bisect the chord in the point D.



Draw the radii CA, CB, then (*by art.* 39) the angle CBA=the angle CAB, and as the angles at D are right, the angle ACD must be equal to the angle BCD (*by art.* 36.) Hence in the triangles ACD, BCD, we have the angle ACD equal to the angle BCD, CA=CB and CD common to both triangles, consequently (*by art.* 37) AD =DB, that is, AB is bisected at D.

XLIV.

If from the centre C of the circle ABE there be drawn a perpendicular CD, to the chord AB, and it be continued to meet the circle in F, it will bisect the arch AFB in F. (See the preceding figure.)

For in the last article it was proved that the angle ACD=the angle BCD, hence (*by art.* 11) the arch AF=the arch FB.

XLV.

Any line bisecting a chord at right angles is a diameter.

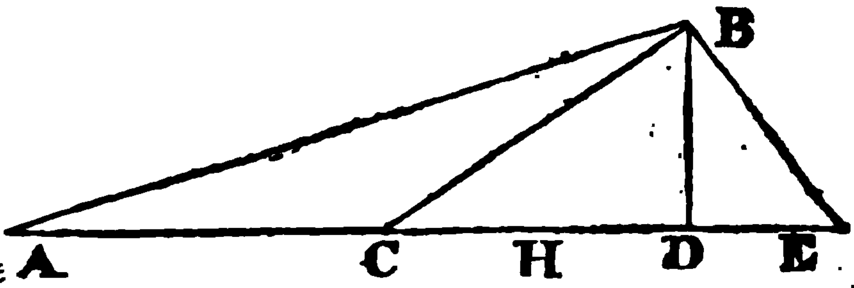
For since (*by art.* 43) a line drawn from the centre perpendicular to a chord bisects that chord at right angles, therefore conversely a line bisecting a chord at right angles, must pass through the centre, and consequently be a diameter.

In any plane triangle ABC, if the line CD be drawn perpendicular to the base AB, dividing it into two segments, AD, DB, and the base AB be bisected in the point H, we shall have,

As the base AB is to the sum of the sides, AC, BC, so is the difference of the sides to twice the distance DH of the perpendicular from the middle of the base.

Dem. With the greater side CB as radius, describe about the centre C the circle BFGE, meeting the other side produced in the points E and F, and the base AB produced in G: join GF and BE. Then AE is the sum, and AF the difference of the sides AC, CB; and since CD is perpendicular to GB, the line GB is bisected in D *(by art.* 43*)* and as AB is bisected in H, the line AG is equal to twice DH. Now in the triangles BAE, GAF, the angles ABE, GFA are equal *(by art.* 41*)* and the angle BAE is equal to GAF *(by art.* 2.*)* therefore the remaining angles AEB, AGF, are equal, and the triangles BAE, GAF, are similar; consequently *(by art.* 54*)* AB : AE :: AF : AG, or twice HD which is the proposition to be demonstrated. Having thus obtained HD, we may find the segments AD, DB, by adding HD to the half base HA or HB and by taking their difference.

LXI.



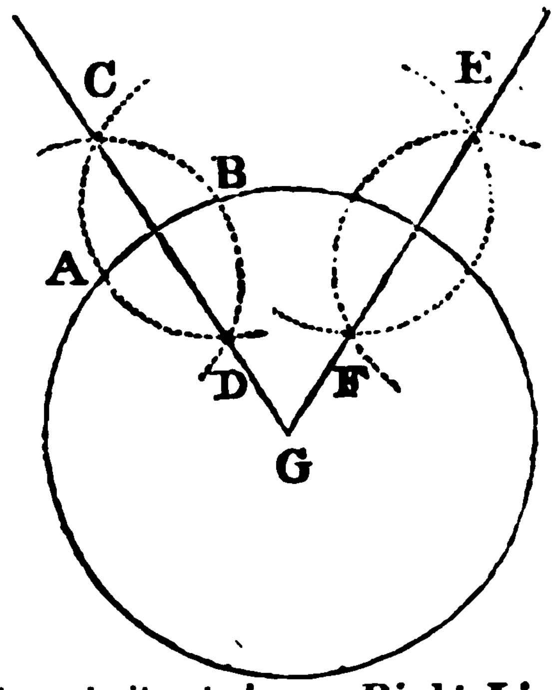
In any plane triangle, the square of radius is to the square of the co-sine of half of either of the angles as the rectangle contained by the two sides including that angle is to the rectangle contained by the half sum of the sides, and that half sum decreased by the side opposite to that angle.

Thus in the triangle CBE, the square of radius is to the square of the co-sine of half the angle C, as the rectangle CB×CE is to $\frac{CB+CE+BE}{2}\times\frac{CB+CE-BE}{2}$.

For continue EC to A, making CA=CB, draw BD perpendicular to CE, bisect CE in H, and join AB. Then (supposing CB to be greater than EB) we have (by art. 60) CE : CB+BE : : CB—BE : $\frac{CB^2-BE^2}{CE}=2.HD$; by adding half this to half the base=CH, we have the segment CD=$\frac{CB^2-BE^2+CE^2}{2.CE}$; to this adding CA or CB, we have AD$=\frac{CB^2-BE^2+CE^2+2CE\cdot CB}{2\cdot CE}=$ $\frac{\overline{CB+CE}^2-BE^2}{2.CE}=\frac{\overline{CB+CE+BE}\times\overline{CB+CE-BE}}{2.CE}$ Again, AD=AC+CD=CB+CD; hence $\overline{AD}^2=CB^2+2CB\cdot CD+CD^2$; also, $BD^2=CB^2-CD^2$; hence $AB^2=AD^2+BD^2=2\cdot CB^2+2CB\cdot CD=2CB\times\overline{CB+CD}=2CB\,.\,AD$; hence $AB^2 : AD^2 :: 2CB : AD=\frac{\overline{CB+CE+BE}\,.\,\overline{CB+CE-BE}}{2CE}$; but AB being radius, AD is the co-sine of the angle A, which is equal to half the angle C (by art. 40;) therefore the square of radius is to square of the co-sine of half the angle C, as the rectangle CE·CB is to the rectangle $\frac{CB+CE+BE}{2}\times\frac{CB+CE-BE}{2}$

The other cases of this proposition may be demonstrated in the same manner.

PROBLEM VIII.

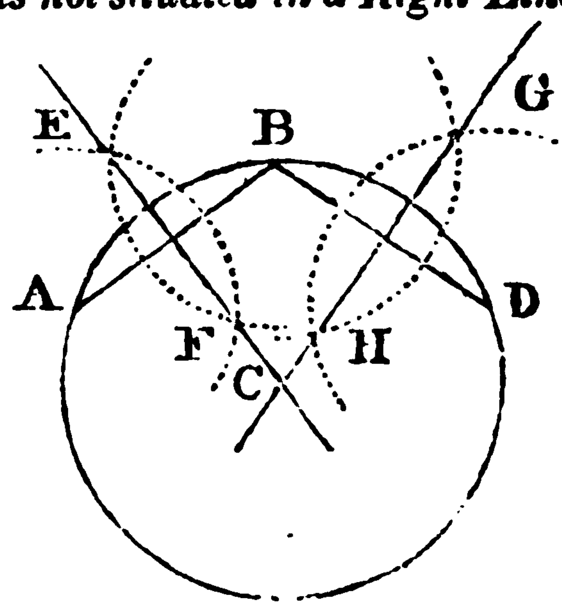


To find the centre of a given Circle.

With any radius, and one foot in the circumference as at A, describe an arch of a circle, as CBD, cutting the given circle in B; with the same extent, and one foot in B, describe another arch CAD, cutting the former in C and D; through C and D draw the line CD, which will pass through the centre of the circle; in like manner may another right line be drawn, as EFG, which shall cross the first right line at the centre required. This construction depends upon Article 43 of Geometry.

PROBLEM IX.

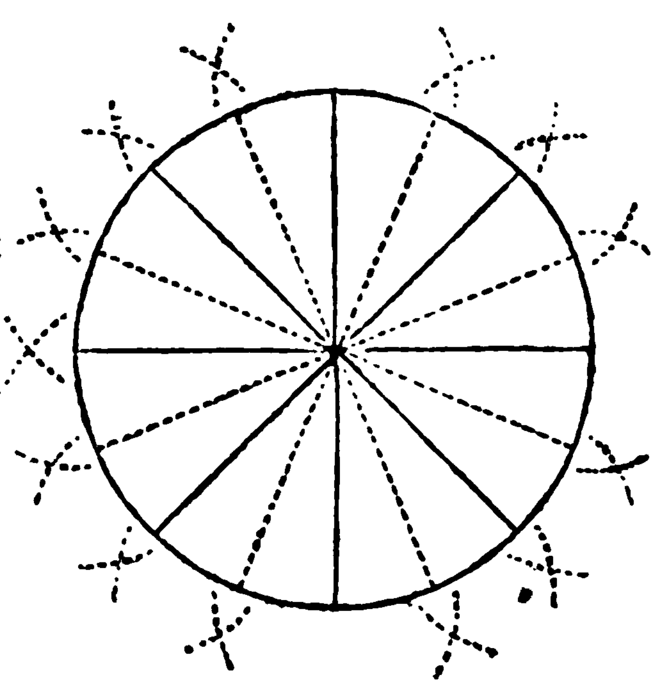
To draw a Circle through any three given points not situated in a Right Line.



Let A, B and D be the given points. Take in your compasses any distance greater than half AB, and with one foot in A describe an arch EF; with the same extent, and one foot in B, describe another arch cutting the former in the points E, F, through which draw the indefinite right line EFC; then take in your compasses any extent greater than half BD, and with one foot in B, describe an arch GH; with the same extent, and one foot in D, describe another arch cutting the former in the points G, H, through which draw the right line GHC, cutting the former right line EFC, in the point C; upon the point C as a centre, with an extent equal to CA, CB, or CD, as radius, describe the sought circle.

PROBLEM X.

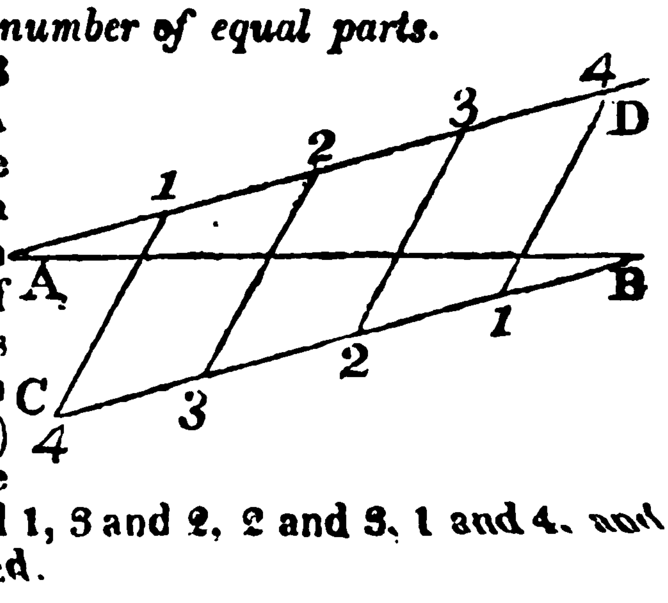
To divide a Circle into 2, 4, 8, 16, or 32, equal parts.



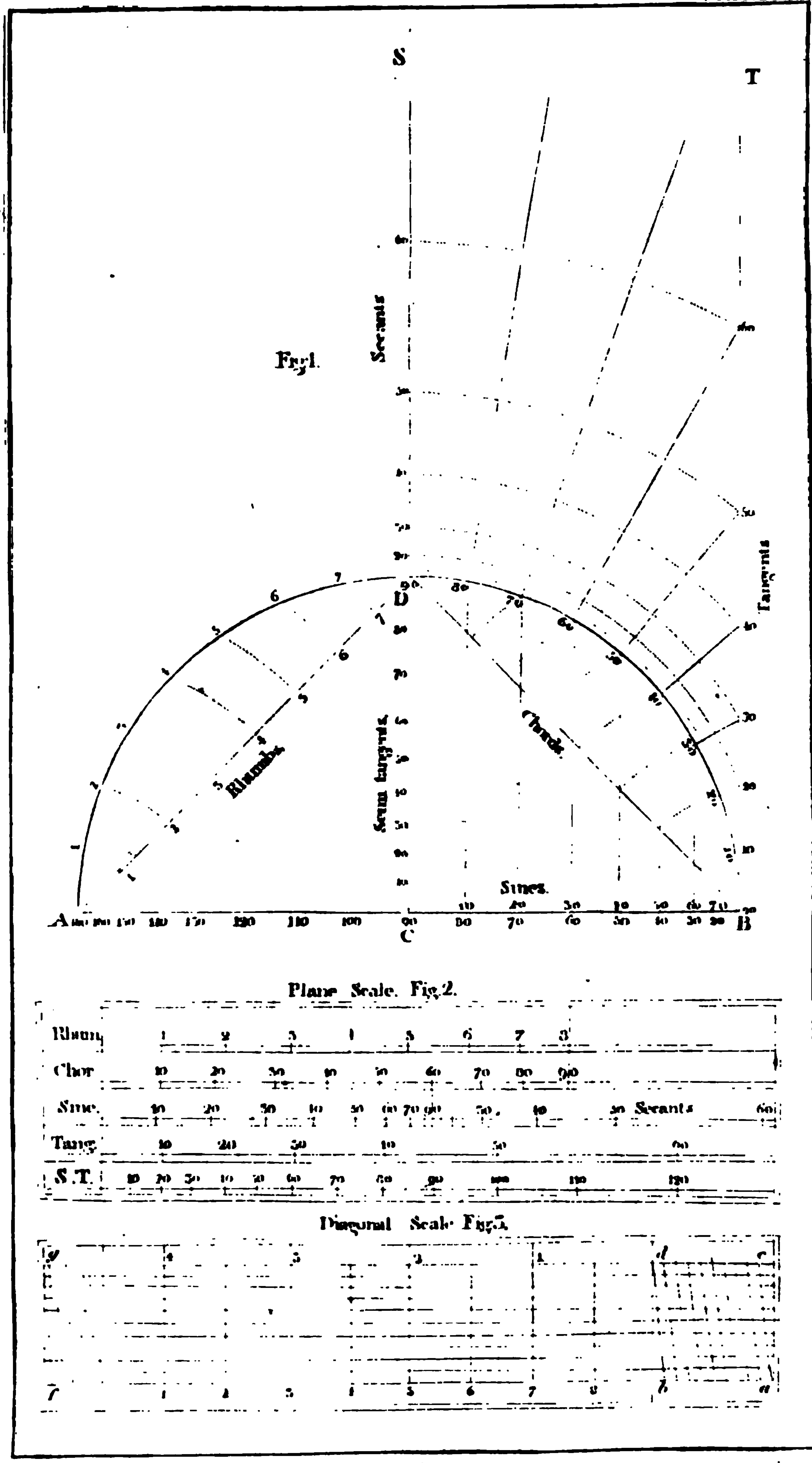
Draw a diameter through the centre, dividing the circle into two equal parts; bisect this diameter by another drawn perpendicular thereto, and the circle will be divided into four equal parts or quadrants; bisect each of these quadrants again by right lines drawn through the centre, and the circle will be divided into eight equal parts; and so you may continue the bisections any number of times. This problem is useful in constructing the mariner's compass.

PROBLEM XI.

To divide a given Line into any number of equal parts.



Let it be required to divide the line AB into five equal parts.—From the point A draw any line AD, making an angle with the line AB; then through the point B draw a line BC parallel to AD; and from A, with any small opening in your compasses, set off a number of equal parts on the line AD, less by one than the proposed number (which number of equal parts in this example is 4;) then from B set off the same number of the same parts on the line BC, then join 4 and 1, 3 and 2, 2 and 3, 1 and 4, and these lines will cut the given line as required.


S
T
Secants
Fig.1.
Tangents
D
C
A
B
Rhumbs
Chords
Semi tangents
Sines
Plane Scale. Fig.2.
Rhum
Chor
Sine
Tang
S.T.
Secants
Diagonal Scale Fig.3.

To calculate COMPOUND INTEREST by Logarithms.

To 100 dollars add its interest for one year; find the logarithm of this sum and reject 2 in the index, then multiply it by the number of years and parts of a year, for which the interest is to be calculated; to the product add the logarithm of the sum put at interest; the sum of these two logarithms will be the logarithm of the amount of the given sum for the given time.

EXAMPLE.

Required the amount of the principal and interest of 355 dollars, let at 6 per cent. compound interest for 7 years?

Adding 6 to 100 gives 106, whose logarithm, rejecting 2 in the index, is		0.02531
Multiplied by		7
Product		0.17717
Principal 355 dollars	log.	2.55023
Sum gives the log. of 533,83	log.	2.72740

Therefore the amount of principal and interest is 533 dollars and 83 cents.

To find the Logarithm-sine, Tangent, or Secant, corresponding to any number of Degrees and Minutes, by Table XXVII.

The given number of degrees must be found at the bottom of the page when between 45° and 135°, otherwise at the top, the minutes being found in the column marked M, which stands on the side of the page on which the degrees are marked; thus, if the degrees are less than 45, the minutes are to be found in the left hand column, &c. and it must be noted that if the degrees are found at the top, the names of hour, sine, co-sine, tangent, &c. must also be found at the top: and if the degrees are found at the bottom, the names sine, co-sine, &c. must also be found at the bottom. Then opposite to the number of the minutes will be found the log-sine, log-secant, &c. in the column marked sine, secant, &c. respectively.

EXAMPLE I.

Required the log. sine of 28° 37′?

Find 28° at the top of the page, directly below which, in the left hand column find 37′; against which in the column marked sine is 9.68029, the log. sine of the given number of degrees; and in the same manner the tangents, &c. are found.

EXAMPLE II.

Required the log. secant of 126° 20′?

Find 126° at the bottom of the page, directly above which, in the left hand column, find 20′; against which, in the column marked secant, is 10.22732 required.

To find the Logarithm-sine, Co-sine, &c. for Degrees, Minutes, and Seconds, by Table XXVII.

Find the numbers corresponding to the even minutes next above and below the given degrees and minutes, and take their difference; then say, as 60″ is to the number of seconds in the proposed number, so is that difference to a correction to be applied to the number corresponding to the least number of degrees and minutes; additive if it is the least of the two numbers taken from the table, otherwise subtractive.

EXAMPLE I.

Required the log. sine of 24° 16′ 48″?

Sine of 24° 16′	9.61382
Sine of 24 17	9.61411
Diff.	29

Then, as 60″ : 48″ :: 29 : 23 which, added to the number corresponding to 24° 16′, gives 9.61405 the log. sine of 24° 16′ 48″.

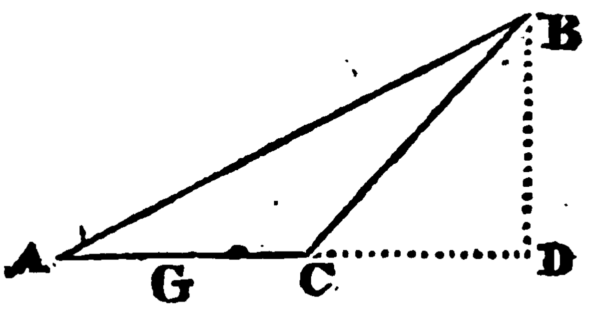
EXAMPLE II.

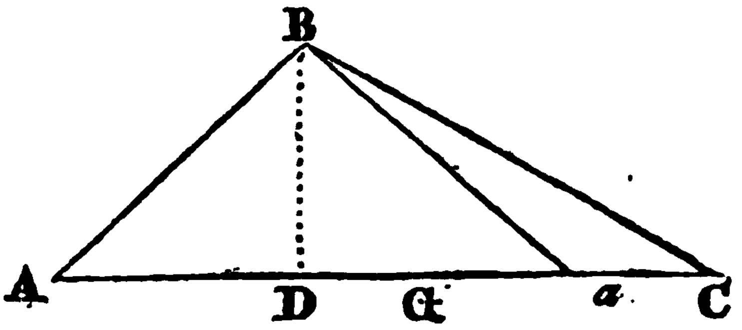
Required the log. secant of 105° 20′ 16″?

Secant of 105.20 log.	10.57768
105.21	10.57722
Diff.	46

Then 60″ : 16″ :: 46 : 12, which, subtracted from the number corresponding to 105° 20′, gives 10.57756, the log. sec. of 105° 20′ 16″.

If the given seconds be $\frac{1}{2}$, $\frac{1}{3}$, $\frac{1}{4}$, $\frac{1}{5}$, or $\frac{1}{6}$, or any other even parts of a minute, the like parts may be taken of the difference of the logarithms, and added or subtracted as above, which may be frequently done by inspection.





Case	Given.	Sought.	Solutions.
1	The angles and side AB.	Side BC. Side AC.	Sine C : side AB : : sine A : side BC. Sine C : side AB : : sine B : side AC.
2 & 3	Two sides AB, BC, and angle C opposite to one of them.	Angle A. Angle B. Side AC.	Side AB : sine C : : side BC : sine A, which added to C, and the sum subtracted from 180° gives B. Sine C : side AB : : sine B : side AC.
4 & 5	Two sides AC, AB, and the included angle A.	Angles C and B. Side BC.	Subtract half the given angle A from 90°, the remainder is half the sum of the other angles. Then say, as the sum of the sides AC, AB is to their difference, so is the tangent of the half sum of the other angles to the tangent of half their difference; which added to and subtracted from the half sum, will give the two angles B and C the greatest angle being opposite to the greatest side. Sine B : side AC : : sine A : side BC.
6	All three sides.	All the angles.	Let fall a perpendicular BD opposite to the required angle; then as AC : sum of AB, BC : : their difference : twice DG, the distance of the perpendicular from the middle of the base; hence, AD, CD are known, and the triangle ABC is divided into two right-angled triangles BCD, BAD: then by cases 4 and 5 of right-angled trigonometry, we may find the angle A or C.
		Either angle, as A.	Either of the angles, as A, may also be found by the following rule. From half the sum of the three sides subtract the side BC opposite to the sought angle; take the logarithms of the half sum and remainder, to which add the arithmetical complements of the logarithms of the sides AB, AC (including the sought angle;) half the sum of these four logarithms will be the logarithmic co-sine of half the sought angle.

In working by logarithms with any of the preceding rules, you must remember, that *the logarithm of the first term of the analogy is to be subtracted from the sum of the logarithms of the second and third terms, the remainder will be the logarithm of the sought fourth term.*

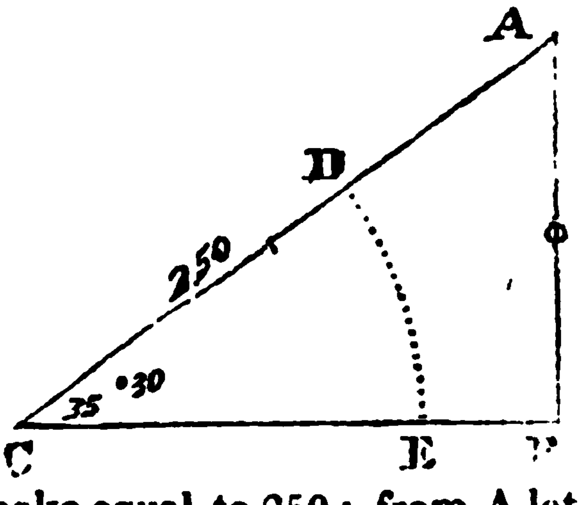
When the first term is radius (whose logarithm is 10.00000) you need only reject an unit in the second left hand figure of the index of the sum of the second and third terms. But when the radius occurs in the second or third term, you must suppose an unit to be added to the second left hand figure of the index of the other term, and subtract therefrom the logarithm of the first term.

RIGHT-ANGLED TRIGONOMETRY.

Solution of the six cases in right-angled Trigonometry.

CASE I.

The angles and hypotenuse given, to find the legs.



Given the hypotenuse AC 250 leagues, and the angle C opposite to the side AB=35° 30′ to find the base CB and perpendicular AB.

BY PROJECTION.

Draw the base CB of any length: with an extent equal to the chord of 60° and on C as a centre, describe the arch DE; from E to D lay off 35°·30′ taken from the line of chords,* through C and D draw the line AC, which make equal to 250; from A let fall the perpendicular AB, to cut CB in B, and it is done; for CB will be 203.5, and AB=145.2.

* In all projections of this kind the angles are measured from the line of chords, the radius used for describing arches by which the angles are to be measured, being equal to the chord of 60°, the sides of the triangles are measured by scales of equal parts as was before observed.

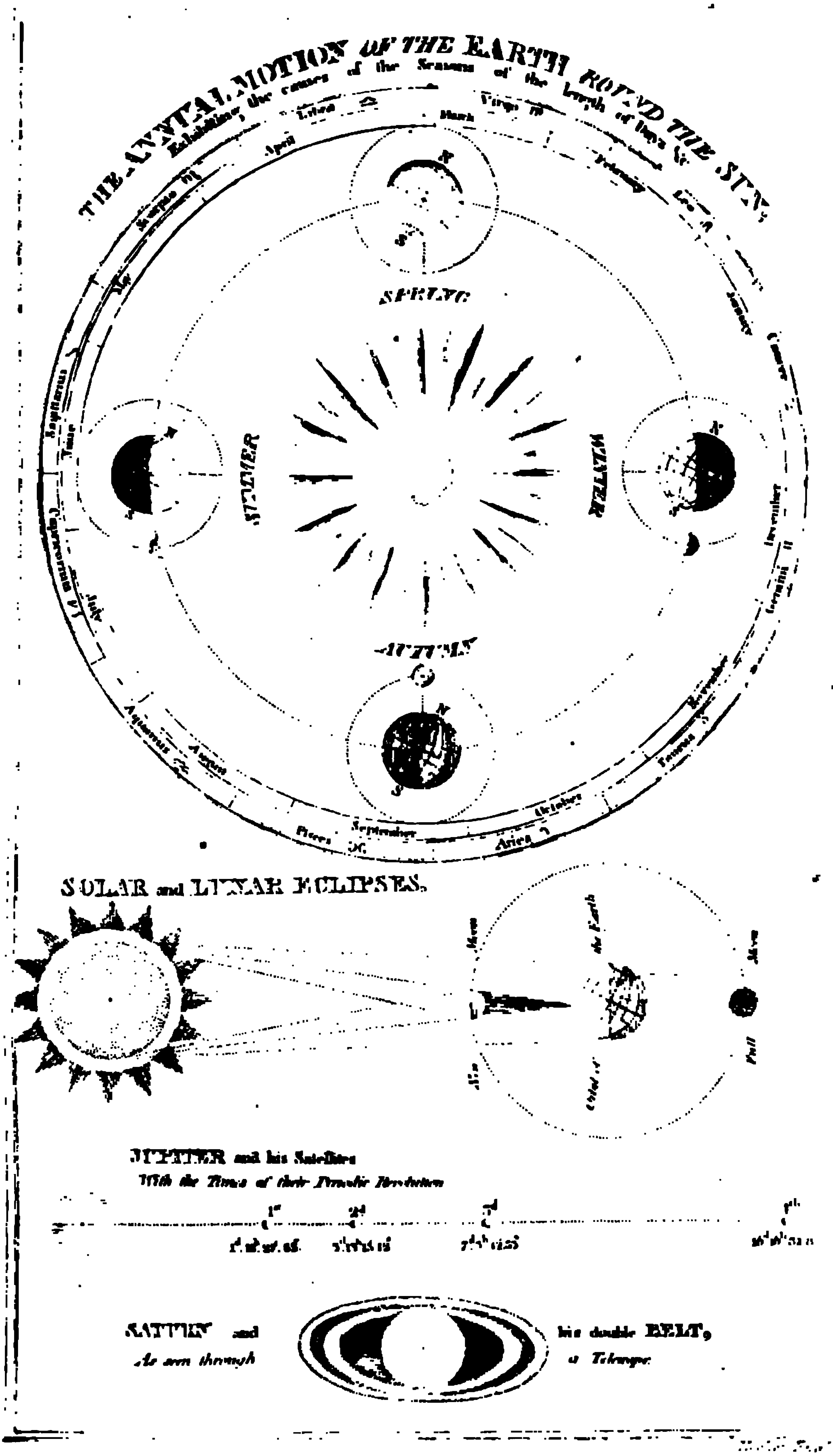

THE ANNUAL MOTION OF THE EARTH ROUND THE SUN
Exhibiting the causes of the Seasons & the length of Days &c.
SPRING
SUMMER
WINTER
AUTUMN
SOLAR and LUNAR ECLIPSES.
JUPITER and his Satellites
With the Times of their Periodic Revolution
SATURN and his double BELT,
As seen through a Telescope

Plate V

PUBLISHED BY EDM. M. BLUNT, for W. HOOKER,
1821.

EXAMPLE III.

Required the difference of latitude between Georgetown and Cape Frio?

Georgetown's lat.	33° 25′ N.
Cape Frio's lat.	23 1 S.
Diff. of lat.	56 24
	60
In miles	3384

EXAMPLE IV.

A ship from latitude 28° 25′ N. sails south 1800 miles, what latitude is she in?

From diff. of lat. 1800 miles, or	30° 00′ S.
Sub. lat. left	28 25 N.
Diff. = lat in	1 35 S.

In the last example it is evident that as the difference of latitude is more than the latitude left, the ship must have crossed the equator, and consequently come into south latitude.

NOTE. When one of the places has no latitude, or is on the equator, the latitude of the other place is their difference of latitude.

EXAMPLE V.

What is the difference of longitude between Cape Ann light-house and Lisbon?

Cape Ann light-house's long.	70° 34′ W.
Lisbon's long.	9 9 W.
Diff. of long.	61 25
	60
In miles	3685

EXAMPLE VII.

What is the difference of longitude between Barcelona and Salem?

Barcelona's long.	2° 12′ E.
Salem's long.	70 52 W.
Diff. of long.	73 4 W.

EXAMPLE IX.

What is the difference of longitude between Manilla and New-York light-house?

Manilla's long.	121° 02′ E.
New-York light-house	74 01 W.
Sum exceeds 180°	195 03
Subtract it from	360 00
Diff. of long.	164 57

EXAMPLE VI.

A ship from Cape Charles, in Virginia, sails eastward till her difference of longitude is 400 miles, what longitude is she in?

Cape Charles' long.	76° 04′ W.
Diff. of long. 400 miles =	6 40 E.
Long. in	69 24 W.

EXAMPLE VIII.

A ship from 15° 40′ E. long. sails westward till her diff. of long. is 27° 15′, what long. is she in?

Long. left	15° 40′ E.
Diff. of long.	27 15 W.
Long. in	11 35 W.

EXAMPLE X.

A ship from longitude 160° 20′ W sails westward until she differs her longitude 41° 20′; what longitude is she in?

Long. left	160° 20′ W.
Diff. of long.	41 20 W.
	201 40
	360 00
Long. in	158 20 E

In the last example the ship has crossed the opposite meridian, and therefore has come into a longitude of a different name.

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	60	
In miles	3384	

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Sub. lat. left	28 25 N.
Diff. = lat in	1 35 S.

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What is the difference of longitude between Cape Ann light-house and Lisbon?

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	60	
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Diff. of long.	164	57

EXAMPLE VI.

A ship from Cape Charles, in Virginia, sails eastward till her difference of longitude is 400 miles, what longitude is she in?

Cape Charles' long.	76°	04' W.
Diff. of long. 400 miles =	6	40 E.
Long. in	69	24 W.

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Fig 1.

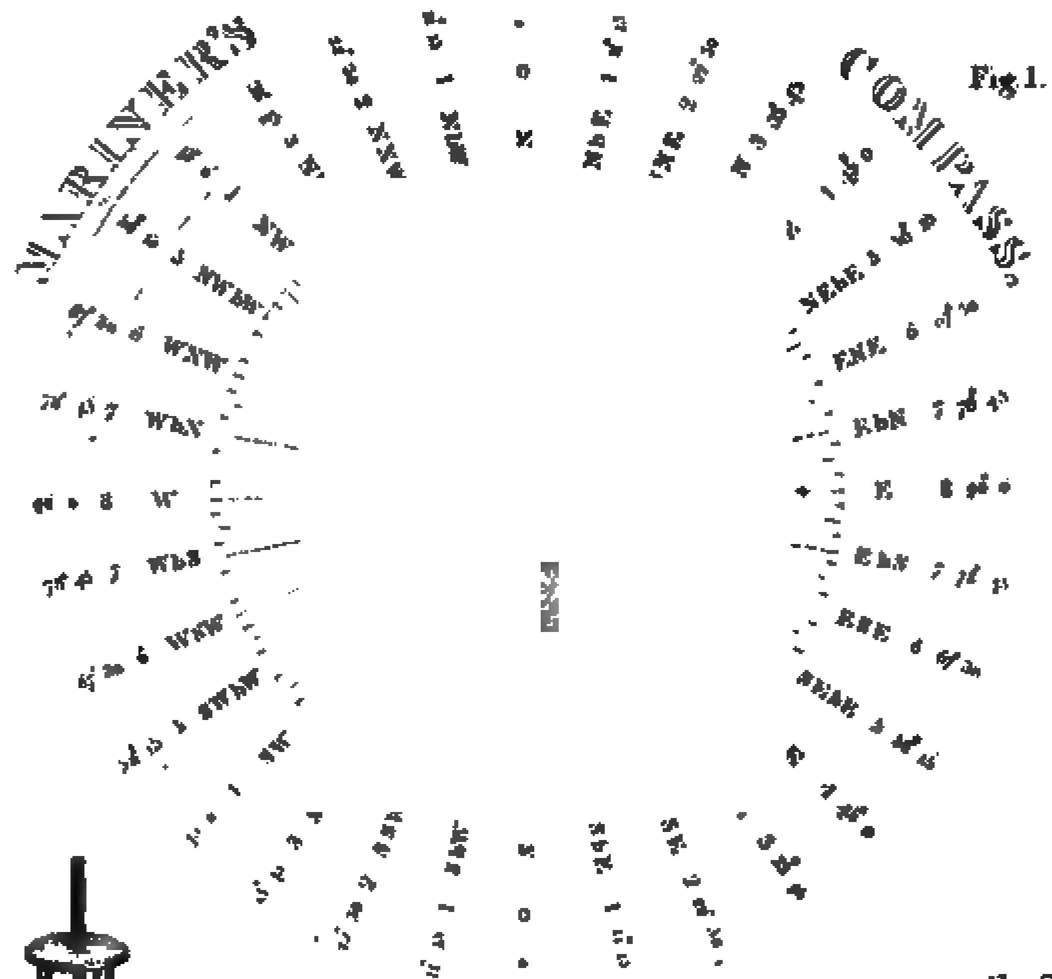
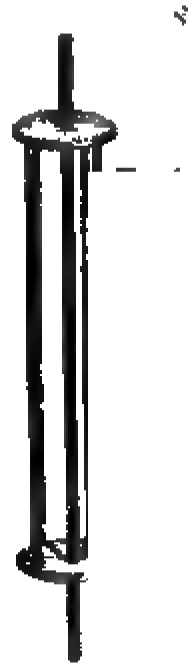


Fig 2



Hooker Sculp

PUBLISHED BY EDM. M. BLUNT, & W. HOOKER,
1821

Hence the ship's distance run is 487.8 miles, and her departure from the meridian is 405.6 easterly.

BY GUNTER.

Extend from radius or 4 points to the course 5 points on the line marked TR, that extent will reach from the difference of latitude 271 to the departure 405.6 on the line of numbers.

2dly. Extend from the complement of the course 3 points to the radius 8 points on the line SR, that extent will reach from the difference of latitude 271 to the distance 488 on the line of numbers.

BY INSPECTION.

Find the course among the points or degrees, and the difference of latitude in its column, against which will stand the distance and departure in their columns.

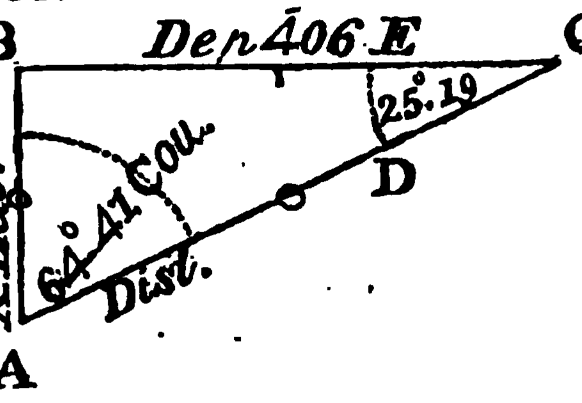
Now, as the difference of latitude 271 is too great to be found in the tables, I divide it by 2, and that gives 135.5 which I find over S. E. by E. or 5 points in the latitude column; against that stand 244, for the distance and 202.9 for the departure, which multiplied by 2 give the distance 488, and the departure 405.8.

CASE III.

Course and departure from the meridian given, to find the distance and difference of latitude.

If a ship sails N. E. by E. ¾ E. from a port in 3° 15′ south latitude, until she depart from her first meridian 406 miles, I demand the distance sailed, and the latitude she is in?

BY PROJECTION.



Draw the meridian AB, upon which erect the perpendicular BC, and set off thereon the departure 406 easterly from B to C; with the chord of 60°, on C as a centre, describe an arch, and set off thereon the complement of the course DE; through D and C draw the line CDA, cutting the meridian in the point A; then AC measured on the same scale before used, gives the distance 449, and AB 192, the difference of latitude.

BY LOGARITHMS.

By making the departure BC radius.		By making the distance AC radius.	
As radius 4 points	10.00000	As sine course 5¾ pts.	9.95616
Is to the departure 406	2.60853	Is to the departure 406	2.60853
So is co-tang. course 5¾ pts.	9.67483	So is radius	10.00000
To the diff. of lat. 192	2.28336	To the distance 449,1	2.65237

From the latitude left	3° 15′ S.
Subtract the difference of latitude 192 miles, or	3 12 N.
The remainder being 3, shows the ship is in the latitude of	0 03 S.

BY GUNTER.

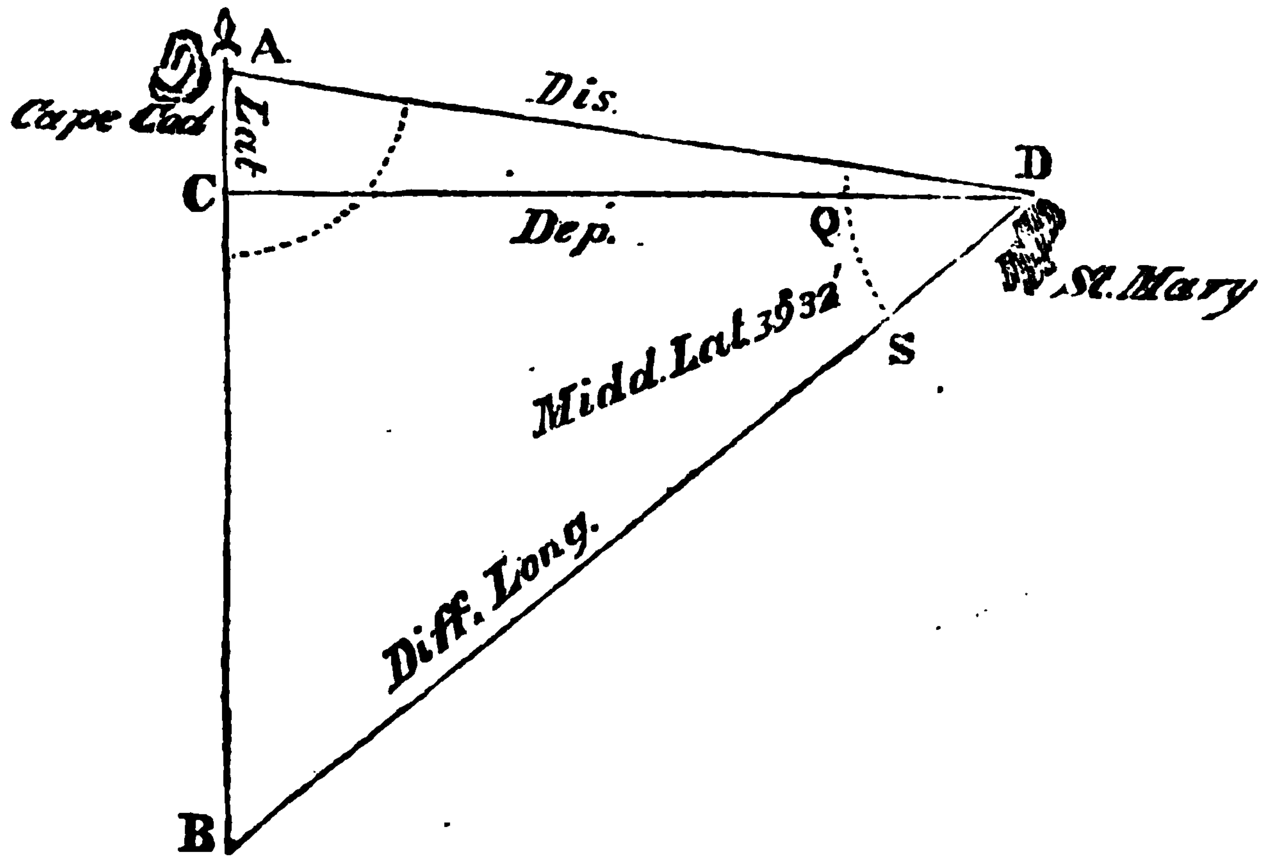
Extend from radius or 4 points to the co-course 2¼ points on the line marked TR; that extent will reach from the departure 406 to the difference of latitude 192 on the line of numbers.

2dly. Extend from the course 5¾ points to radius on the sines, that extent will reach from the departure 406 to the distance 449 miles on the line of numbers.

BY INSPECTION.

Find the course either among the points or degrees, and the departure in its column, against which will stand the distance and difference of latitude in their respective columns.

BY PROJECTION.



Draw the east and west line DC, with the chord of 60° describe the arch QS about the centre D, to cut DC in Q; upon this arch, set off, from Q to S, the middle latitude 39° 32′; through D and S draw the line DB, which make equal to the difference of longitude 2694 miles; from B let fall upon DC the perpendicular BC, which continue towards A making AC equal to the difference of latitude 306 miles;* join AD, and it is done. For by this method of construction, on the principles before explained, A will be the situation of Cape Cod, D the situation of St. Mary; CD will be the departure, which being measured will be found to be 2078 miles; the distance will be represented by AD, which being measured will be found to be 2099 miles, and the course from Cape Cod to St. Mary, will be represented by the angle CAD=81° 37′; therefore the course will be S. 81° 37′ E. or E. ¾ S. nearly.

NOTE. The course is put S. 81° 37′ E. because St. Mary being in a less northern latitude than Cape Cod, is to the southward of it; it is also to the eastward of Cape Cod, because it is in a lesser western longitude.

BY LOGARITHMS.

To find the departure (by Theorem I.)

As radius 90°	10.00000
Is to diff. of long. 2694	3.43040
So is co-sine mid. lat. 39° 32′	9.88720
To the departure 2078	3 31760

To find the distance.

As radius 90°	10.00000
Is to the diff. lat. 306	2.48572
So is sec. of course 81° 37′	10.83626
To the distance 2099	3 32198

NOTE The log. of the departure above found 3,31760 is rather less than the log. of 2078=3.31765; but in finding the course by the departure, I have used the quantity found at the first operation, and shall do the same in all future calculations.

To find the course.

As diff. of lat. 306	2.48572
Is to radius 45°	10.00000
So is the departure 2078	3.31760
To tang. of course 81° 37′	10.83188

NOTE. The course may be found without the departure, by Theo V. Middle Latitude Sailing.

As the diff. of lat. 306	2 48572
Is to the diff. of long. 2694	3.43040
So is co-sine mid. lat. 39° 32′	9.88720
	13.31760
	2.48572
To tang. of course 81° 37′	10.83188

BY GUNTER.

Extend from the radius or 90° to 50° 28′ the complement of the middle latitude, on the line of sines; that extent will reach from the difference of longitude 2694, to the departure 2078, on the line of numbers.

2dly. Extend from the difference of latitude 306, to the departure 2078,

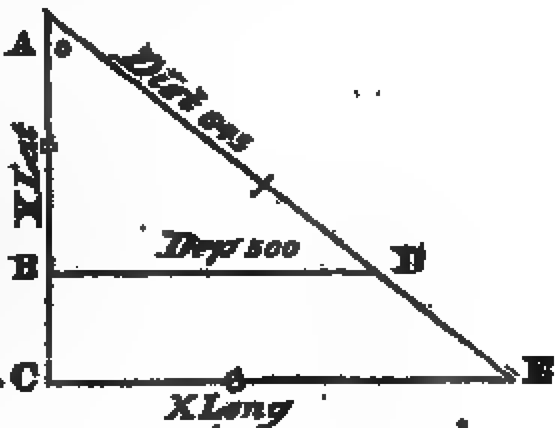
* If the place A be to the southward of D, the line AC should be set off upon the line CB, from C towards B.

CASE VII.

One latitude, distance sailed, and departure given, to find the course, difference of latitude, and difference of longitude.

A ship in the latitude of 49° 30′ N. and the longitude of 25° W. sails south-easterly 645 miles, making 500 miles departure; required the course steered, and the latitude and longitude in?

BY PROJECTION.



Draw the meridian ABC, and on any point of it draw BD perpendicular thereto and make it equal to the departure 500 miles, with an extent equal to the distance 645 miles in your compasses, and one foot on D as a centre describe an arch to cut AB in A, join AD; then will AB be the proper difference of latitude 407.5 miles, and the angle BAD will be the course 50° 49′; hence we have the other latitude, and the meridional difference of latitude, to which make AC equal; and draw CE parallel to BD, meeting AD produced in E; then will CE be the difference of longitude, 722,6 miles.

BY LOGARITHMS.

To find the course.

As the distance 645	2.80956
Is to the radius 90°	10.00000
So is the departure 500	2.69897
To sine of course 50° 49′	9.88941

To find the diff. of long.

As radius 45°	10.00000
Is to the mer. diff. lat. 589	2.77012
So is tang. course 50° 49′	10.08879
To diff. long. 722.6	2.85891

Or thus,

To find the diff. of lat.

As radius 90°			10.00000
Is to the distance 645			2.80956
So is co-sine course 50° 49′			9.80058
To diff. l. 407,5 = 6° 48′ S.			2.61014
Lat. left	49 30 N.	M. par.	3426
Lat. in	42 42 N.	M. par.	2839
Mer. diff. lat.			589
Long. left	25° 00′ W.		
Diff. long.	12 03 E.		

gular distance of the two wires. This angular distance being obtained, the observer may, by means of it, estimate, at each observation, how much the place where the contact was observed was elevated above, or depressed below, the plane passing through the eye and the middle line between the two parallel wires: the correction in Table XXXV. corresponding to this angle, is to be subtracted from the observed angular distance of the objects; thus if the distance between the wires was 3°, one of them would be elevated above the plane 1° 30′, and the other depressed as much below it; and if in taking an observation the point of contact was estimated to be one-third part of the distance from the middle towards either wire, the angle of elevation or depression would be one-third part of 1° 30′ or 30′; and if the observed distance was 100°, the correction in Table XXXV. would be 19″, subtractive from the observed angle, which would therefore be 100°—19″= 99° 59′ 41″. In general it will not be necessary to attend to this correction.

To measure the distance between the Sun and Moon.

Screw on the telescope, and place the wires parallel to the plane of the instrument; then if the index glass is half silvered and half blacked, and the sun very bright, raise the plate before the silvered part of the glass, and with the screw L raise the telescope to the transparent part of the horizon glass; turn down one or more of the dark glasses according to the brightness of the sun; then hold the sextant so that its plane may pass through the sun and moon: if the sun be to the right hand of the moon, the sextant is to be held with its face upwards; if to the left hand, the face is to be held downward: with the instrument in this position, look directly at the moon through the telescope, and move the index forward till the sun's image is brought nearly into contact with the moon's nearest limb; then fix the index by the screw under the sextant, and make the contact perfect by means of the tangent screw; at the same time move the sextant slowly, making the axis of the telescope the centre of motion, by which means the objects will pass each other, and the contact be more accurately made, observing that the point of contact of the limbs must always be observed in the middle between the parallel wires. The observation being thus made, the index will point out the distance of the nearest limbs of the sun and moon.

To measure the distance between the Moon and a Star.

Turn down the green screen if the moon is bright, and direct the plane of the instruments through both objects, with its face upwards, if the moon is to the right of the star; but if to the left, the face is to be held downwards; look at the star through the telescope and the transparent part of the horizon glass, and move the index till the moon's image appears nearly in contact with the star; fasten the index, move the sextant round the axis of the telescope as in measuring the distance of the sun and moon, and turn the tangent screw, till the coincidence of the star and the *enlightened or round limb* of the moon is perfect; observing that the point of contact of the limb of the moon and star must always be in the middle between the parallel wires. The observation being thus made, the index will point out the distance of the enlightened limb of the moon from the star, whether it be the farthest or nearest limb.

If the observer suspect that the mirrors, or coloured glasses, have not their surfaces exactly parallel, he may verify them as follows:

Verification of the parallelism of the index glass.

This verification is to be made ashore, by observing the angular distance of two well defined objects, whose distance exceeds 90° or 100° (having previously well adjusted the instrument) then taking out the central mirror and turning it, so that the edge which was formerly uppermost may now be nearest the plane of the instrument; rectify its position and again measure the distance of the two objects; half the difference between these two distances will be the error of the observed angle arising from the defect of pa-

tral mirror A; and the horizon index MD carries the telescope GH and the horizon mirror B; both indices are furnished with verniers and tangent screws at O and N.

The *central mirror* A is placed on the central index immediately above the centre of the instrument; the plane of this mirror makes an angle of about 30° with the middle line of the index, and is adjusted perpendicular to the plane of the instrument, by means of the screws placed on the back part of the frame of the mirror.

The *horizon glass* B is placed on the horizon index near the limb, so as to interfere as little as possible with the rays proceeding from objects situated on the opposite side of that index with respect to the central mirror. The horizon glass is adjusted perpendicular to the plane of the instrument in a similar manner to that of a horizon glass of a sextant; and in some circles this mirror is moveable about an axis perpendicular to the plane of the instrument; by which means the situation with respect to the telescope may be adjusted.

The *telescope* GH, attached to the other end of the horizon index, is an astronomical one inverting the observed objects, and has two parallel wires in the common focus of the glasses, distant from each other between two and three degrees. These wires, at the time of observation, must be placed parallel to the plane of the instrument. To effect this, marks are made on the eye-piece, and on the tube at G, and by making them coincide, the wires may be brought to their proper position. The telescope may be raised or depressed by two screws I, K, so as to be directed to any part of the horizon glass; and, by means of the graduations on the two standards *i*, *k*, the telescope may be rendered parallel to the plane of the instrument.

There are two sets of *coloured glasses* (fig. 3, 4) each set usually containing four glasses of different shades; the glasses of the larger set (fig. 4) which are placed before the central mirror at *a*, *a*, should have each about half the degree of shade with which the corresponding glasses (fig. 3) of the other set, placed at C, are tinged—because the rays from the luminous object pass twice through the coloured glass placed before the central mirror, and only once through the other. The glasses placed at *a*, *a*, are kept tight in their places by small pressing screws at their ends, or by slides passing in front, through perforations in the stems of their frames: when fixed for observation they make an angle of about 85° with the plane of the instrument, by which means the image from the coloured glass is not reflected to the telescope. When the angle to be measured is between 5° and 35°, one of the largest set is to be fixed at *a*, *a*; in other cases, one of the smaller set is to be placed in the socket C. The reason of using the large glass is this—when the small glass is placed at C, it intercepts the direct light of the luminous object in its passage towards the central mirror, if the object happens to be situated within the angular space, included by the lines from the centre A, by the sides of the frame of the glass placed at C. This is avoided by using the larger glasses.

The *handle* (fig. 5) is of wood, and is fixed to the back of the instrument immediately under the centre. By this it is held during the time of observation.

The *ventelle* (fig. 6) is used in terrestrial observations to diminish the light of the object seen directly, to render it equal in brightness to that of the objects seen by reflection: this is performed by putting the ventelle in the socket D, and raising or depressing it till the objects appear of equal brightness.

There are two *adjusting tools* of the form represented in fig. 7; they are exactly of the same size, and their height is nearly equal to that of the central mirror; they may be used in adjusting the central mirror perpendicular to the plane of the instrument, and in making the axis of the telescope parallel to that plane.

The instrument, as we have now described it, is the same as it was left by De Borda; Mr. Troughton has since suggested the improvement of fixing to the horizon index the arch WSPR, and providing it with two sliding pieces U, X, in order to facilitate the fixing the indices at their proper

right and left of the central glass; for in this case the glass is perpendicular to the plane of the instrument; otherwise, it must be adjusted by means of the screws till the two images coincide.*

By examining this adjustment in different parts of the limb, it will be known if the limb be in the same plane. If any difference should be found, the central glass must be so fixed that the reflected image of the limb may appear as much above the direct image in some places as below it in others.

To set the horizon glass perpendicular to the plane of the instrument.

The central glass being previously adjusted, and the telescope directed to the line separating the silvered from the transparent part of the horizon glass, hold the instrument nearly vertical, and move either index till the direct and reflected image of the horizon, seen through the telescope, coincide; then incline the instrument till it is nearly horizontal, and if the images do not separate, the horizon glass is perpendicular to the plane of the instrument; but if they do separate, the position of the glass must be rectified by means of the screws in its pedestal.

This adjustment may be also made by directing the sight through the telescope to any well defined object; then, if by moving the central index, the reflected image passes exactly over the object seen directly, the glass is perpendicular; otherwise its position must be adjusted by means of the screws attached to the pedestal of the glass.

A planet, or star of the first magnitude, will be a good object for this purpose. If the sun is used, one of the coloured glasses must be placed at C and another at D.

To make the axis of the telescope parallel to the plane of the instrument.

The telescope may be raised or depressed by means of two screws attached to the standards *i*, *k*, (fig. 2) and passing through two pieces of brass connected with the tube of the telescope. On each of these pieces is a mark or index by which the telescope is to be adjusted. For, by bringing the indices to the same mark on each standard, the telescope will be parallel to the plane of the instrument.†

To find that division to which the horizon index must be placed to render the mirrors parallel when the central index is on 0.

Place the central index on 0; direct the telescope to the horizon glass, so that the line joining the silvered and transparent parts of that glass may appear in the middle of the telescope; hold the instrument vertically, and move the horizon index, till the direct and reflected horizons agree—and the division shown by the horizon index will be that required.

This adjustment may also be made by measuring the diameter of the sun in contrary directions; thus, the central index being fixed on 0, place a dark glass at C and another at D; direct the telescope (through the transparent part of the horizon glass) to the sun, and move the horizon index till his reflected image appear in the telescope; bring the upper edge of the direct image to coincide with the lower of the other, and note the angle shown by the index; then, by moving the horizon index, bring the lower edge of the

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* When the instrument is furnished with adjusting tools, this adjustment may be made in the following manner. Set the two tools on opposite parts of the limb at T and L; place the eye at *e*, at nearly the same height as the upper edge of the tools, so that part of the tool at T may be hid by the central glass; move the central index till the reflected image of the tool nearest the eye appears in the central glass at the side of the other tool seen directly; then if the upper edges of the tools are apparently in the same straight line, the central glass is perpendicular to the plane of the instrument; otherwise its position must be adjusted by the screws at the back of the frame.

† If you suspect that the marks on the standards are inaccurate, you may examine them in the following manner. Lay the circle horizontally on a table; place the two adjusting tools on opposite parts of the limb at T and L; and at about 12 or 15 feet distance let a well defined mark be placed, so as to be in the same straight line with the tops of the tools; then raise or lower the telescope till the mark is apparently in the middle between the two wires: then the axis of the telescope will be parallel to the plane of the instrument, and the difference (if any) between the divisions pointed out by the indices on the graduation of the standards *i*, *k*, (fig. 2) will be the error of the indices, by knowing which, it will be easy in future adjustments to make allowance for the error.

want of parallelism in the surfaces of the smaller dark glasses; for if those glasses give too great an angle by an observation to the right, they give too little by the same quantity by an observation to the left. It is not so with the larger glasses placed at *aa*, because the incidence of the rays on those glasses is more oblique in one observation than in the other, so that the errors do not wholly balance each other; however, as those glasses are used only in measuring angles less than 35°, in which the errors are nearly the same as if the incidence of the rays was perpendicular, the errors of those glasses will also nearly compensate each other in the cross observations; and if those observations only were used, it would be unnecessary to verify the dark glasses:—Even when taking observations to the right, or observations to the left, the error of the dark glasses would be destroyed, if the glass was turned at each observation, and the number of observations was even; but there are some cases in which an angle can only be measured by one observation, then it would be necessary to allow for the error of the dark glass, if the distance was required to be found within a few seconds.

ON PARALLAX, REFRACTION,

AND DIP OF THE HORIZON.

PARALLAX (or diurnal parallax) is *the difference between the true altitude of the sun, moon, or star; if it were observed at the centre of the earth, and the apparent altitude observed at the same instant by a spectator at any point on the surface of the earth.*

Thus in plate IX. fig. 3, let ABC be the earth, C its centre, A the place of a spectator, EDF part of the moon's orbit, *e d* G part of the orbit of a planet, and KZ part of the starry heavens. Then if at any time the moon be at D, she will be referred to the point H by a spectator supposed to be placed at the centre of the earth, and this is called the *true place* of the moon, but the spectator at A will refer the moon to the point *b*, and this is called the *apparent place* of the moon, the difference H *b* (or the angle HD*b*=ADC) is called the moon's *parallax in altitude*, which is evidently greatest when the moon is in the horizon at E, being then equal to the arch K I, and decreases from the horizon to the zenith and is there nothing. The parallax is less as the objects are farther from the earth: thus the parallax of a planet at *d* is represented by *a b*, being less than that of the moon at D; and the horizontal parallax K*f* of the planet is less than the horizontal parallax KI of the moon. As the parallax makes the objects appear lower than they really are, it is evident that the parallax must be added to the apparent altitude to obtain the true altitude. Having the horizontal parallax, the parallax in altitude is easily found by the following rule—*As radius is to the co-sine of the apparent altitude, so is the horizontal parallax to the parallax in altitude.* This rule may be easily proved: for in the triangle CAE we have CE : CA : : radius : sine CEA; and in the triangle CDA we have CD (or CE) : CA : : sine CAD : sine CDA; hence we have, radius : sine CEA : : sine CAD : sine CDA, but CEA=horizontal parallax, CDA=parallax in altitude, and sine CAD=co-sine app. alt. Hence we have radius : co-sine app. alt. : : sine hor. par. : sine par. in alt. but the parallaxes of the heavenly bodies being very small the sines are nearly proportional to the parallaxes, hence we may say, as radius : co-sine app. alt. : : hor. par. : par. in alt.

The sun's mean parallax in altitude is given in Table XIV. for each 5° or 10° of altitude. The moon's horizontal parallax is given in the 7th. page of the month of the Nautical Almanac, for every noon and midnight at the meridian of Greenwich.

Plate IX.

Fig.1.

[illegible]

Fig.2.

PUBLISHED BY EDM. M. BLUNT, for W. HOOKER,
1821.

compass when elevated above the horizon ;) the difference between this and the true azimuth found by calculation will be the variation.

Some years after the discovery of the variation, it was found that it did not remain constant : for the easterly variation observed in England gradually decreased till the needle pointed to the true north and then increased to the westward, and is now above two points.

As all the courses steered by a compass must be corrected for the variation to obtain the true courses, it is of great importance to the navigator to know how to find the variation at any time: to do this it is necessary to find the magnetic amplitude or azimuth of a celestial object, which may be done as follows :

*To observe an amplitude by an azimuth compass.**

When the centre of the sun is about one of his diameters† above the horizon, turn the compass round in the box, until the centre of the sun is seen through the narrow slit which is in one of the sight vanes, exactly on the thread which bisects the slit in the other ;‡ at that instant push the stop which is in the side of the box against the edge of the card, and the degree and parts of a degree which stand against the middle line on the top will be the magnetic amplitude of the sun at that time ; which is generally reckoned from the east or west point of the compass.

To observe an azimuth by an azimuth compass.

Turn the compass round in the box until the centre of the sun is seen through the narrow slit which is in one of the sight vanes, exactly on the thread which bisects the slit on the other, or until the shadow of the thread falls directly along the line of the horizontal bar,‡ the card is then to be stopped, and the degree and parts of a degree which stand against the middle line of the stop, will be the magnetic azimuth of the sun at that time, which is generally reckoned from the north in north latitude, and from the south in south latitude.‖ At the time of making this observation, you must also observe the altitude of the sun, in order to obtain the true azimuth.

What is here said of the sun, is alike applicable to the moon, planets, and stars.

TO FIND THE TRUE AMPLITUDE.

RULE.

By logarithms.—*To the log-secant of the latitude (rejecting 10 in the index) add the log. sine of the sun's declination ;*** the sum will be the log. sine of the true amplitude or distance of the sun from the east or west point, towards the north in north declination, but towards the south in south declination.*

By inspection.—*Find the declination at the top of Table VII. and the latitude in the side column ; under the former and opposite the latter will be the true amplitude.* When great accuracy is required, you may proportion for the minutes of latitude and declination.

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* The figure of an azimuth compass, furnished with sight vanes, is given in Plate VI. fig. 5. The card of this compass is similar to that of a common compass.

† The observation is to be taken at that altitude on account of the dip, refraction and parallax, the correction of altitude depending on these causes being in general nearly equal to the sun's diameter.

‡ If the instrument is furnished with a magnifying glass fixed to one of the vanes, you may (instead of proceeding as above) turn the compass-box until the vane is directed towards the sun, and when the bright speck (or rays of the sun collected by the magnifying glass) falls upon the slit of the other vane, or upon the line in the horizontal bar, the card is to be stopped, and the divisions read off as above.

‖ If the compass vibrate considerably at the time of making the observations, it would be conducive to accuracy to take several azimuths and altitudes, and to take the mean of all the azimuths and all the altitudes, and work the observation with the mean azimuth and altitude. The same is to be observed in taking an amplitude.

** The declination of the sun at noon is given in the Nautical Almanac, and in Table IV. and must be corrected for the longitude of the ship and the hour of the day, by means of Table V.

EXAMPLE I.

Required the sun's true amplitude at rising, in the latitude of 39° 0′ N. on the 22d. of December, 1820?

BY LOGARITHMS.

Latitude	39°	0′	log. sec.	0.10950
Sun's declin.	23	28	log. sine	9.60012
True ampli.	30	49	log. sine	9.70962

BY INSPECTION.

Under the declination 23° 28′ and opposite the latitude 39° stands the true amplitude 30° 49′.

Hence the true bearing or amplitude of the sun at rising is E. 30° 49′ S. and at setting it is W. 30° 49′ S.

EXAMPLE II.

Required the moon's true amplitude at setting, in the latitude of 35° 8′ N. when her declination is 13° N.?

BY LOGARITHMS.

Latitude	35°	8′	log. sec.	0.08734
Moon's declin.	13	0	log. sine	9.35209
True ampli.	15	58	log. sine	9.43943

BY INSPECTION.

Under the declination 13°, and opposite the latitude 35° stands 15° 56, which is nearly the true amplitude; the exact value may be found by finding the amplitude for 36° latitude, and proportioning the difference for the miles in the latitude.

Hence the true amplitude at setting is W. 15° 58′ North, and at rising E. 15° 58′ N.

EXAMPLE III.

Required the sun's true amplitude in the latitude of 42° 30′ N. when his declination was 20° N.?

BY LOGARITHMS.

Latitude	42°	30′	log. sec.	0.13237
Sun's declin.	20	N.	log. sine	9.53405
True ampli.	27	38	log. sine	9.66642

BY INSPECTION.

Under the declination 20° and opposite the latitudes 42° and 43°, stand 27° 24′ and 27° 53′; the mean of these gives the true amplitude for the latitude of 42° 30′ =27° 38′.

Hence the amplitude at setting is W. 27° 38′ N. and at rising E. 27° 38′ North.

To find the true azimuth at any time.

At the time of observing the magnetic azimuth, you must also observe the altitude of the object: this altitude must be corrected as usual for the dip, parallax, refraction,* &c. in order to obtain the true altitude; you must also find the declination of the object,† and the latitude of the place of observation, and then the true azimuth may be calculated by the following rule.

Rule. Add together the polar distance,‡ the latitude, and the true altitude, take the difference between the half sum and the polar distance, and note the remainder. Then add together the log. secant of the latitude, the log. secant of the altitude, (rejecting 10 in each index) the log. co-sine of the half sum, and the log. co-sine of the remainder; half the sum of these four logarithms will be the log. co-sine of half the true azimuth, which being doubled will give the true azimuth, reckoned from the north in north latitude, but from the south in south latitude.

* In observations of the altitude of the sun's lower limb (by a fore observation) it is usual to add 12′ for the effect of dip, parallax, and semi-diameter. The refraction is to be subtracted from the sum, and the remainder will be the true altitude nearly.

† The declination is to be found according to the directions in the note in the last page.

‡ The polar distance of the sun, moon, or star, is the distance from the elevated pole, and is found by subtracting the declination of the object from 90°, when the latitude and declination are of the same name, but by adding to 90° when of different names.

EXAMPLE I.

In latitude 51° 32′ N. the sun's true altitude was found to be 39° 28′, his declination being then 16° 38′ N.—required the true azimuth?

Polar distance	73°	22′		
Latitude	51	32	Secant	0.20617
Altitude	39	28	Secant	0.11239
Sum	164	22		
Half sum	82	11	Co-sine	9.13355
Polar distance	73	22		
Remainder	8	49	Co-sine	9.99484
				2)19.44695
½ Sum log. co-sine	58°	4′		9.72347
		2		
True Azimuth	116	8	from the north.	

The logarithm 9.72347 of this example is also the co-sine of 121° 56′, which doubled gives another azimuth 243° 52′, the former being 116° 8′. One of these corresponds to an observation in the forenoon, the other to an afternoon observation.

EXAMPLE II.

In latitude 42° 16′ S. the sun's true altitude was found to be 18° 40′, his declination being then 7° 38′ N.—required the true azimuth?

Polar distance	97°	38′		
Latitude	42	16	Secant	0.13076
Altitude	18	40	Secant	0.02347
Sum	158	34		
Half sum	79	17	Co-sine	9.26940
Polar distance	97	38		
Remainder	18	21	Co-sine	9.97734
			Sum	19.40097
½ Sum log. co-sine	59	53		9.70048
		2		
True azimuth	119	46	from the south.	

QUESTIONS TO EXERCISE THE LEARNER.

Question I. Given the sun's altitude corrected for dip, refraction, &c. 20° 46′, his declination 17° 10′ S. and the latitude of the place 40° 38′ N. required the true azimuth?

Answer. 137° 50′ from the north.

Question II. What is the sun's azimuth in the latitude of 26° 30′ N. in the forenoon, when his correct central altitude is 24° 28′ and his declination 22° 40′ N.?

Answer. 75° 44′ from the north.

Question III. At the island of St. Helena the sun's true central altitude was found to be 30° 23′ in the forenoon, his declination being then 22° 58′ S.—required the azimuth at that time?

Answer. 72° 21′ from the south.

Question IV. What point of the compass did the star Aldebaran bear on, in the latitude of 34° 23′ S. on January 1, 1804, when the correct altitude of that star was 22° 26′?

Answer. 130° 16′ from the south.

Having the true magnetic amplitude or azimuth, to find the variation.

Having found the true and magnetic amplitude or azimuth, the variation may be easily deduced therefrom by the following rule, in which the amplitude is reckoned from the east or west point of the horizon, and is called north when to the northward of those points, but south when to the south-

Rule. Find from Table IV. the daily variation of the sun's declination on the day of observation. Then *to the constant logarithm* 9.1249 *add the log. co-sine of the latitude of the place, the log. sine corresponding to the elapsed time between the observations found in the column P. M. the Prop. Log. of the daily variation of the sun's declination, and the Prop. Log. of the elapsed time**, *estimating hours and minutes as minutes and seconds, the sum, rejecting 30 in the index; will be the Prop. Log. of the correction to be applied to the western azimuth, by subtracting when the sun is approaching towards the northern hemisphere, otherwise by adding.*† The azimuth thus corrected is to be used in estimating the variation instead of the observed azimuth.

It is not necessary in this calculation to find the latitude or declination to any great degree of accuracy, which is the greatest advantage of the method: another of the advantages consists in being able to take a great number of observations, and applying the correction at one operation to the variation deduced from the mean of all the observations; so that, when great accuracy is required, as in taking observations ashore, this method may be used with success; and it is evident that it is alike applicable to the moon or any heavenly body, but the observations must be taken in the same place, as it would increase the calculation considerably, to make an allowance for the change of place, as well as for the change of declination; and it would be better in this case to calculate each observation separately by the rules before given.

EXAMPLE.

Suppose that on the 10th of April, 1820, in the latitude of 42° 29′ N. long. 50° W. the sun's morning azimuth was observed to be S. 54° 24′ E. and in the evening, when the sun was at the same altitude, was S. 39° 46′ W. the elapsed time between the observations being 6h. 20 m.—required the variation?

Constant logarithm	9.1249
Latitude 42° 29′ co-sine . . . :	9.8677
Elapsed time 6h. 20m. Sine . .	9.8676
Daily variation of declination 22′ P. L. .	.9128
Elapsed time 6h. 20m. taken as 6′ 20″ P. L.	1.4536
Corr. western azimuth 11′ nearly P. L.	1.2268
Western azimuth S. 39 46 W.	
Corrected azimuth S. 39 35 W.	
Morning azimuth S. 54 24 E.	
Difference . . . 14 49	

The half of which 7° 24′ is the variation, which is easterly, because the greater azimuth S. 54° 24′ E. is easterly.

The variation, thus found, is to be allowed on all courses steered by the compass to obtain the true courses. To make this allowance, you must look towards the point of the compass the ship is sailing upon, and allow the variation from it *towards the right hand, if the variation be east, but to the left hand, if the variation be west.* Thus, if a ship steer S. E. with one point westerly variation, the true course will be S. E. by E. If the variation is one point easterly, the course will be S. E. by S.

In the following Table are collected a few observations of the variation, made at different times, and in different places.

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* The elapsed time may be determined by any common watch, but if none was used in the observations, it may be determined as follows. If one of the observed azimuths was east and the other west, take half their sum, otherwise half their difference, and to the log. sine of this half sum (or half difference) add the log secant of the sun's declination, and the log. co-sine of the sun's correct altitude at the time of taking the azimuth, the sum (rejecting 20 in the index) will be the log sine to be used in the above calculation, and this logarithm will correspond to the elapsed time, marked in the column P. M of Table XXVII.

† In this rule it is supposed that the bearing of the sun, by the afternoon observation, is to the westward of the meridian by compass; but if there be a great variation, that bearing might be to the eastward of the meridian by the compass, and in that case the correction of the western azimuth must be applied in a contrary manner to the above directions.

Places observed at.	Latitude.			Longitude from Greenwich.			Year of Observation.	Variation Observed.		
(Cambridge, Mass.)	42°	23′	N.	71°	8′	W.	1708	9°	0′	W.
							1742	8	0	W.
							1757	7	20	W.
							1761	7	14	W.
							1763	7	0	W.
							1782	6	46	W.
Boston.	42	23	N.	71	4	W.	1742	8	0	W.
Beverly (town.)	42	36	N.	70	52	W.	1781	7	2	W.
Salem.	42	33	N.	70	52	W.	1805	5	57	W.
							1808	5	20	W.
London.	51	31	N.	0	5	W.	1580	11	15	E.
							1672	2	30	W.
							1780	22	41	W.
Paris.	48	50	N.	2	20	E.	1550	8	0	E.
							1660	0	0	
							1769	20	0	W.
Funchal Road.	32	38	N.	17	5	W.	1792	18	35	W.
St. Croix Road.	28	27	N.	16	16	W.	1792	17	35	W.
Bonavista.	16	6	N.	22	53	W.	1792	12	36	W.
St. Jago (Praya Bay.)	14	52	N.	23	30	W.	1769	11	10	W.
							1792	12	48	W.
Isle of May.	15	4	N.	22	46	W.	1792	12	00	W.
Ascension.	7	56	S.	14	21	W.	1678	1	0	E.
							1776	10	45	W.
St. Helena.	15	55	S.	5	51	W.	1677	0	40	E.
							1776	13	15	W.
							1794	16	16	W.
Tristan d'Acunha.	37	7	S.	11	38	W.	1792	7	0	W.
Cape of Good Hope.	34	26	S.	18	23	E.	1776	21	0	W.
Cape Lagullas.	34	53	S.	20	10	E.	1600	0	0	
							1692	11	0	W.
							1776	21	40	W.
							1790	23	30	W.
Island St. Paul.	37	56	S.	77	28	E	1677	23	30	W.
							1803	19	30	W.
Isle of Bourbon.	20	52	S.	55	31	E.	1795	15	33	W.
Java Head.	6	46	S.	104	50	E.	1676	3	10	W.
							1786	0	54	W.
Batavia.	6	10	S.	106	51	E.	1793	0	30	W.
At Sea.	29	10	N.	23	52	W.	1795	15	00	W.
At Sea.	27	00	N	23	43	W.	1795	15	44	W.
At Sea.	15	28	N.	20	48	W.	1795	12	05	W.
At Sea.	12	14	N.	20	05	W.	1795	11	39	W.
At Sea.	9	47	N.	20	15	W.	1795	11	48	W.
At Sea.	8	54	N.	20	15	W.	1795	10	50	W.
At Sea.	5	46	N.	20	54	W.	1795	11	00	W.
At Sea.	3	16	N.	21	27	W.	1795	10	47	W.
At Sea.	0	0		24	20	W	1795	8	43	W.
At Sea.	2	33	S	24	54	W.	1795	7	05	W.
At Sea.	5	48	S.	26	54	W.	1795	5	24	W.
At Sea.	7	59	S	27	54	W.	1795	4	14	W.
At Sea.	9	27	S.	27	55	W.	1795	3	33	W.
At Sea.	13	19	S.	26	58	W.	1795	3	54	W.
At Sea.	19	47	S.	25	56	W.	1795	2	50	W.
At Sea, near Trinidad.	20	28	S.	28	44	W.	1796	2	35	W.
At Sea.	21	32	S.	25	27	W.	1795	2	25	W.
At Sea.	23	43	S.	23	45	W.	1795	2	31	W.
At Sea.	28	11	S.	18	45	W.	1795	5	28	W.
At Sea.	35	05	S.	6	0	W.	1795	11	10	W.
At Sea.	36	33	S.	0	15	E.	1795	13	40	W.
At Sea.	36	12	S.	4	16	E.	1795	15	19	W.
At Sea.	37	20	S.	7	25	E.	1795	16	57	W.
At Sea.	36	45	S.	10	27	E.	1795	24	33	W.
At Sea.	21	54	S.	53	41	E.	1795	13	59	W.
At Sea.	0	0		32	35	W.	1795	3	0	W.

EXAMPLE III.

Being at sea in lat. 50° 40′ N. per account, when the sun's declination was 20° 0′ S. at 10h. 17m. A. M. per watch, the sun's correct central altitude was found to be 17° 13′, at 11h. 17m. A. M. per watch, the correct central altitude was found to be 19° 41′. Required the latitude?

	Times.			Alt.	Nat. Si.		
	H.	M.	S.			Lat. by acct. 50° 40′	Sec. 0.19803
						Declin. 20 00	Sec. 0.02701
2 Obs.	11	17	0	19° 41′	=33682		
1 Obs.	10	17	0	17 13	=29599	Log. ratio	0.22504
Elaps. time	1	0	0	Diff. Nat. Si.	4083	Its log.	3.61098
½ Ela. time	0	30	0	Its log. from col. half elapsed time is			0.88430
	1	0	50	In col. of mid. time corresponding to			4.72032
True time	0	30	50	from noon.		Its log. from col. of rising	2.95599
						Log. ratio subtract	0.22504
					538	Nat. num. of	Log. 2.73095
					33682	Nat. sine greatest alt.	
					34220	Nat. co-sine ☉'s merid. zen. dist.	69° 59′ N.
						☉'s declination - - - - -	20 0 S.
						Latitude - - - - - - - -	49 59 N.

But as this latitude differs 41 miles from that by account, it will be proper to repeat the operation, using the latitude last found instead of the latitude by account.

	H.	M.	S.		
				Lat. last found 49° 59′	Sec. 0.19178
				Decl. 20 0	Sec. 0.02701
				Log. ratio	0.21879
				Log. diff. N. sines	3.61098
½ Elapsed time	0	30	0	Its log.	0.88430
Middle time	1	0	0	Its log.	4.71407
True time from noon	0	30	0	Its log. in col. of rising is	2.93223
				Log. ratio	0.21879
				517 Nat. numb. of log.	2.71344
				33682 Nat. sine gr. alt.	

Nat. co-sine ☉'s mer. zen. dist.	70° 0′ N.	34199
Declination - - - - - - -	20 0 S.	
Latitude - - - - - - - -	50 0 N.	

The latitude last found, differing only one mile from that used in the operation, may be depended on as the true latitude. From this example it appears that the calculation may be repeated with very little additional trouble, but few alterations being necessary.

EXAMPLE IV.

Being at sea in the latitude 60° 0′ north by account, when the sun was on the equator, and consequently had no declination, at 1h. 0m. P. M. per watch, his correct central altitude was 28° 53′, and at 3h. 0m. P. M. per watch, the correct central altitude was 20° 42′. Required the true latitude?

	Times. H. M. S.	Alt.	Nat. Si.		
				Lat. by acc. 60° Sec.	0.30103
				Declin. 0 Sec.	0.00000
1 Obs.	1 0 0	28° 53'	= 48303		
2 Obs.	3 0 0	20 42	= 35347	Log. ratio	0.30103
Elap. time	2 0 0		12956	Its log.	4.11247
½ Ela. T.	1 0 0	Its log. in col. of ½ elaps. time			0.58700
	2 0 10	Its log. in col. of mid. time			5.00050
Ti. fr. N.	1 0 10	Its log. from col. of rising			3.53482
				Log. ratio	0.30103
			1713	Nat. numb. of log.	3.23379
			48303		
Nat. cos. ☉'s mer. zen. dist. 59° 59'			50016		

Hence the latitude was 59° 59' N. the sun having no declination.

EXAMPLE V.

The latitude by account being 7° 40' N. and the sun's declination 22° 47' N. at 7h. 25m. 40s. A. M. the true altitude of the sun's centre was 22° 30' and at 10h. 31m. 48s. A. M. was 63° 40'; required the ship's true latitude?

FIRST OPERATION.

	Times. H. M. S.	Alt.	Nat. Si.		
2 Obser.	10 31 48	63° 40'	89623	Lat. by acct. 7° 40' Sec.	0.00390
				Declin. 22 47 Sec.	0.03528
1 Obser.	7 25 40	22 30	38268	Log. ratio	0.03918
Elap. time	3 6 8	Diff. Nat. Sines	51355	Log. of the difference	4.71058
½ Ela. time	1 33 4	Its logarithm			0.40339

	H. M. S.		
Middle time	3 1 24		5.15315
½ Elaps. time sub.	1 33 04		
2d. obser. before noon	1 28 20		
Its log. in col. of rising			3.86547
Log. ratio subt.			0.03918
Nat. number correspond.	6703	log.	3.82629
Nat. sine of gr. alti. add	89623		
Nat. cos. ☉'s meri. zen. dist. 15° 35' S.	96326		
☉'s declination 22 47 N.			
Ship's latitude resulting 7 12 N.			

As the latitude by account differs from the computed latitude, the operation must be repeated.

SECOND OPERATION.

Lat. last found 7° 12'	Sec.	0.00344
☉'s declina. 22 47	Sec.	0.03528
Log. ratio		0.03872
Log. of diff. of Nat. sines		4.71058
Log. of ½ Elaps. time		0.40339
Middle time (H. M. S.) 3 1 9		5.15269
½ Elaps. time 1 33 4		
2 obs. before noon 1 28 5		

Log. of (H. M. S.) 1 28 5		3.86304
Log. ratio subt.		0.03872
Nat. number	6673	log. 3.82432
Nat. sine of gr. alti.	89623	
☉'s mer. Z. dis. n. cos.	96296	= 15° 39' S.
☉'s declination		22 47 N.
Ship's lat. resulting		7 08 N.

In the former examples we have considered both altitudes as taken at the same place or station; but as that is seldom the case at sea, the necessary correction for any alteration of station must be made as follows:

But as the latitude by computation differs considerably from that by account, the work must be repeated.

	H.	M.	S.
½ Elapsed time	1	50	0
Middle time	0	10	0
Time from noon	1	40	0

	Latitude last found	48° 57′	Sec.	0.18262
	Declination	23 28	Sec.	0.03749
	Log. ratio			0.22011
	Diff. N. sine 2432		Its log.	3.38596
			Its log.	0.33559
	Its log.			3.94166
	Its log. in col. of rising			3.97170
	Log. ratio			0.22011
5644	Nat. number of		log.	3.75159
24615				
30259	Nat. cos. mer. zen. distance	72° 23′ N.		
	Declination	23 28 S.		
	True latitude	48 55 N.		

This latitude, differing only two miles from that used in the computation, may be depended upon as the true latitude of the ship at the time of the second observation. If the first altitude had not been corrected, the computed latitude would have been found=48° 40′ N.

EXAMPLE VII.

Sailing N. E. ½ E. by compass, at the rate of 9 knots an hour, at 0h. 31m. 40s. P. M. per watch, the altitude of the sun's lower limb was 28° 20′ above the horizon of the sea, the eye being elevated 20 feet above the surface of the water, and the sun's bearing by compass S. by W. and at 2h. 58m. 20s. P. M. by watch, the altitude of the sun's lower limb was 16° 41′ above the horizon, the eye being elevated as before, the latitude by account, at the time of the last observation, 48° 0′ north, and the declination 13° 17′ south. Required the true latitude at taking the last observation?

The correction of these altitudes for semi-diameter, parallax, and dip was 12 miles additive, which makes them 28° 32′ and 16° 53′; the refraction corresponding to the first was 2 miles, and for the second 3 miles, by subtracting which we have the true central altitudes 28° 30′ and 16° 50′. Now the elapsed time between the observations was 2h. 26m. 40s. during which the ship sailed 22 miles (at 9 miles per hour) in the direction of N. E. ½ E. per compass, the bearing of the sun at the first observation S. by W. being 12½ points distant from the ship's course, and as 12½ points want 3½ of 16 points, I enter Table I. and find the course 3½ points and distance 22, corresponding to which in the latitude column is 17 miles, which subtracted from the first altitude 28° 30′ leaves the corrected first altitude 28° 13′; with this and the second altitude 16° 50′, I calculate the latitude in the following manner:

	H.	M.	S.						
				Alt.	Nat. Si.	Lat. by account	48° 0′	Sec.	0.17449
1 Obser.	0	31	40	28° 13′	47281	Declin.	13 17	Sec.	0.01178
2 Obser.	2	58	20	16 50	28959				
						Log. ratio			0.18627
Elaps. time	2	26	40	Diff. Nat. sine	18322	Its log.			4.26298
½ Elap. time	1	13	20	Its log. from col. of ½ elapsed time					0.50232
	1	46	20	In col. of middle time corresponding to					4.95157
	0	33	00	Its log. from col. of rising					3.01488
				Log. ratio					0.18627
				Nat. sine g. alt.	47281				
					674	Nat. number of		log.	2.82861
				Nat. co-sine mer. zen. dist.	47955	=61° 21′ N.			
				Declination		13 17 S.			
				Latitude		48 4 N.			

complement of latitude; then *add together the zenith distance, co-latitude, and polar distance, from half their sum subtract the zenith distance, and note the remainder; then add together the log. co-secant of the co-lat. (this and all the other logs. being found in Table XXVII.) the log. co-secant of the polar distance (rejecting 10 in each index) the sine of the half sum and the sine of the remainder, half the sum of these four logarithms being found among the log. co-sines, will correspond in one of the adjoined columns to the time of day.*

The two preceding examples are thus worked by this method.

EXAMPLE I.

	90° 0′		90° 0′		90° 0′	
☉'s cor. alt.	13 40	Latitude	51 30	☉'s dec.	6 34	
Zen. dist.	76 20	Co-lat.	38 30	Pol. dist.	96 34	

Zen. dist.	76 20		
Co-lat.	38 30	Co-secant	0.20585
Pol. dist.	96 34	Co-secant	0.00286
Sum	211 24		
½ Sum	105 42	Sine	9.98349
Zen. dist.	76 20		
Rem.	29 22	Sine	9.69055
			2)19.88275
		Co-sine	9.94137

Co-sine 9.94137 corresponding to which in the column A. M. is 8h. 7m. 9s. the time of day, which agrees with the other method.

EXAMPLE II.

	90° 0′		90° 0′		90° 0′
☉'s cor. alt.	15 54	Latitude	39 54	☉'s dec.	17 28
Zen. dist.	74 6	Co-lat.	50 6	Pol. dist.	72 32

Zen. dist.	74 6		
Co-lat.	50 6	Co-sec.	0.11511
Pol. dist.	72 32	Co-sec.	0.02050
Sum	196 44		
½ Sum	98 22	Sine	9.99535
Zen. dist.	74 6		
Remainder	24 16	Sine	9.61382
			2)19.74478
		Co-sine	9.87239

Co-sine 9.87239 corresponding to which in the column P. M. is 5h. 34m. 27s. the time of day, which agrees nearly with the first method.

By the preceding method you may find the beginning or ending of the twilight, by calculating the hour when the sun's zenith distance is 108° (or when the sun is 18° below the horizon;) for by observation it has been found that the twilight begins or ends when the sun is at that distance from the zenith.

EXAMPLE.

Required the time of beginning and ending of the twilight, June 23, 1830, at Boston?

Zen. dist.	108° 0′.		
Co-lat.	47 37	Co-secant	0.13156
Pol. dist.	66 33	Co-secant	0.03744
Sum	222 10		
½ Sum	111 5	Sine	9.96991
Zen. dist.	108 0		
Remainder	3 5	Sine	8.73069
		Sum	18.86960
Half sum		Co-sine	9.43480

Half sum Co-sine 9.43480 which corresponds to 2h. 6m. 20s. A. M. and 9h. 53m. 40s. P. M. Therefore, the first appearance of the twilight in the morning was at 2h. 6m. 20s. and the end of it in the evening at *9h. 53m. 40s.*

THIRD METHOD.

If the sun or star's declination, and the latitude be both north or both south, take their difference, but if one be north and the other south, take their sum, and from the natural co-sine of this difference or sum subtract the natural sine of the true altitude (both being found in Table XXIV.); find the log. of their difference in Table XXVI., add thereto the log. secant of the latitude from Table XXVII., and the log. secant of the sun or star's declination (from the same Table) rejecting 10 in each index; the sum of these three logarithms being found in the column of rising, (Table XXIII.) the hours, minutes, and seconds corresponding will be the apparent time from noon, if the altitude of the sun was taken; but if a star was observed, the corresponding time will be the horary distance of the star from the meridian.

The two preceding examples are thus worked by this third method.

EXAMPLE I.

Latitude	[illegible]			Secant 0.20565
Declination	[illegible]			Secant 0.00[illegible]
Sum	[illegible]	Nat. co-sine	72393	
Sun's corr. altitude	[illegible]	Nat. sine	.3627	
		Differ.	.3266	Log. [illegible]636
				[illegible]7567 corresponding
to which in the column of rising is			h. [illegible]m. 1s.	
Subtracted from 12h. leaves the true time			[illegible]	
		Time per watch	[illegible]	
		Watch too fast	[illegible] 51	agreeing with the former methods.

EXAMPLE II.

Latitude	[illegible]			Secant 0.1[illegible]
Declination	[illegible]			Secant 0.02060
Difference	[illegible]	Nat. co-sine	[illegible]	
Corr. altitude	[illegible]	Nat. sine	.7[illegible]	
		Differ.	3[illegible]	Log. [illegible]
				[illegible]4075 corresponding
to which in the column of rising is	h. [illegible]m. 17s.	agreeing nearly with the other methods.		
Time per watch	[illegible] 0			
Watch too slow	[illegible] 27			

To find the apparent time by an altitude of a fixed star.

Correct the observed altitude for the dip and refraction (the dip being generally 4 minutes when the observation is taken on the deck of a common sized vessel) find the ship's latitude at the time of observation, and the star's right ascension and declination in Table VIII.* then add together the star's correct altitude, the ship's latitude, and the polar distance; from the half sum subtract the star's altitude, and note the remainder. Then add together the log. secant of the latitude, the log. co-secant of the polar distance, rejecting 10 in each index, the log. co-sine of the half sum, and the log. sine of the remainder, half the sum of these four logarithms will be the log. sine of half the hour angle; take out the corresponding time in the column marked P. M. (Table XXVII.) and apply it to the star's right ascension, by subtracting when the star is east of the meridian, or adding when west of the meridian, the sum or difference will be the right ascension of the meridian. From the right ascension of the meridian (increased by 24 hours if neces-

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* The right ascensions and declinations of the stars in Table VIII. are [illegible] for the beginning of 1820, and must be reduced to the time of observation by the [illegible] variation [illegible] in the same Table. When very great accuracy is required, the right ascension and declination thus obtained, must be corrected for the Aberration and Nutation [illegible] explained [illegible] precepts of Tables XLII. XLIII.; but in general these corrections may be neglected.

EXAMPLE II.

Suppose that on April 16, 1820, sea account, in lat. 48° 57′ N. and long. 66° W. the observed altitude of Aldebaran when west of the meridian was 22° 25′, and the dip 4′; required the apparent time at the ship?

	H.	M.	S.			
By Table VIII. for the year 1820, R. As. Aldeb.	4	25	36	Dec. 16°	8′ N.
Variation for 3½ months			1	Var.	0
Star's right ascension	4	25	37	Dec. 16	8 N.
				90	
				P. dist. 73	52

Obs. alt. Aldeb.	22°	25′		
Dip		4		
	22	21		
Refraction		2		
Cor. alt. Aldeb.	22	19		
Latitude	48	57	Secant	0.18262
Pol. dist.	73	52	Co-sec.	0.01745
Sum	2)145	8		
½ Sum	72	34	Co-sine	9.47654
Alt.	22	19		
Remainder	50	15	Sine	9.88584
			Sum	2)19.56245
			½ Sum sine	9.78122

corresponding to which, in the column P. M. is

	h.	m.	s.
(column P. M.)	4	57	24
Star's right ascension	4	25	37
Right ascension of the meridian	9	23	1
April 16, sea account, is April 15, by N. A. when ☉'s rt. as. noon	1	34	12
Approximate time at ship	7	48	49
Long. 66° W. in time	4	24	
App. time at Greenwich	12	12	49

Sun's right ascen.	April 15,	1h.	34m.	12s.
	April 16,	1	37	54
Daily difference			3	42

the correction of Table XXXI. corresponding is 1m. 53s. which being subtracted from the approximate time at the ship 7h. 48′ 49″

leaves the apparent time at the ship 7 46 56 P. M.

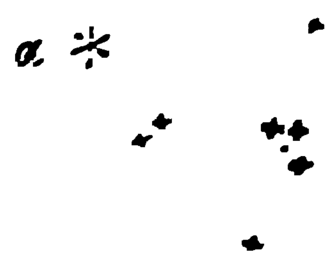
This method of obtaining the time by the stars would be accurate if a good horizon could be obtained; but as that is not always the case, it is best to regulate your watch by the sun.

To regulate a watch by equal altitudes of the sun.

A watch may be regulated on shore by observing in the morning and evening the times when the sun is at the same altitude,* for the middle between these times would be the apparent time of noon by the watch if the declination of the sun remained the same during the observation; but if the declination varies, as is generally the case, the apparent time of noon determined in this manner (which for distinction we shall call the *middle time*) must be corrected for the change of declination by an equation, called the *equation of equal altitudes*, and the middle time thus corrected will be the

* The altitudes should be taken when the sun rises or falls fast. The best time for observation is when the bearing of the sun is east or west. In general two or three hours from noon will be sufficient. An artificial horizon, formed by a vessel filled with mercury, may be used in taking these altitudes.

ALDEBARAN.

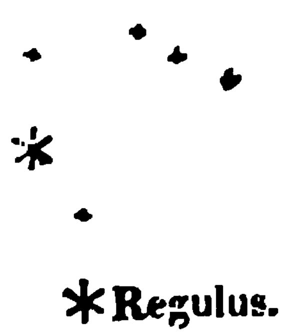


About 35° E. from α Arietis, and 14° S. E. from the Pleiades or Seven Stars, is the bright star Aldebaran. Near this star, to the westward, are six or seven stars of the third or fourth magnitude, forming with Aldebaran a figure resembling the letter V, as is represented in the adjoined figure, where Aldebaran is marked α. At the distance of 23° from this star, in a S. E. direction, are three very bright stars, situated in a straight line near to each other, forming the belt of Orion.

POLLUX.

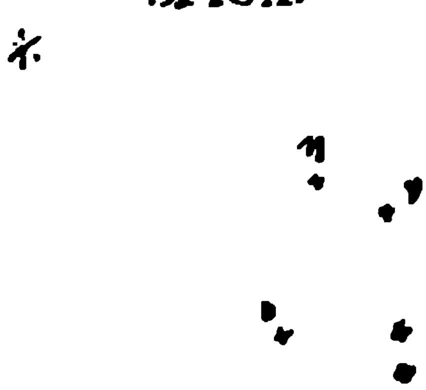
At the distance of 45° from Aldebaran, in the direction of E. N. E. is the Star Pollux, which is a bright star, though not of the first magnitude. N. W. from it, distant 5°, is the star Castor, of nearly the same magnitude, and you will almost always sweep both at once; the southernmost is the one to be used.

REGULUS.



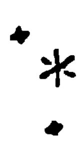
E. by S. ½ S. from Pollux, at the distance of 37½°, is the star Regulus, of the first magnitude; to the northward of this star, (at the distance of 8°) is a star of the second magnitude; near to these are five stars of the third magnitude; the whole forming a cluster resembling a sickle, represented in the adjoined figure, Regulus being in the extremity of the handle. A line drawn from the northern polar star, through its pointers, passes about 12° to the eastward of Regulus.

SPICA.



E. S. E. from Regulus, at the distance of 54°, is the star Spica of the first magnitude, with no very bright star near it: S. W. from this star, at the distance of about 16°, are five stars of the third or fourth magnitude, situated as in the adjoined figure; the two northernmost of these stars κ, ν, form a straight line with Spica, and by this mark it may be easily discovered. A line drawn from the northern polar star, through the middle star of the tail of the Great Bear, will pass near to Spica.

ANTARES.



E. S. E. from Spica, at the distance of 46 degrees, is the star Antares, in 26 degrees of south declination; it is a remarkable star, of a reddish colour; on each side of it, to the W. N. W. and S. S. E. about 2° distant, is a star of the third or fourth magnitude, no very bright star being near.

α AQUILÆ.

N. E. from Antares, at the distance of 60° is the very bright star α Aquilæ; N. N. W. from which, at 2° distance, is a star of the third magnitude, and S. S. E. at 3° distance, another star of a lesser magnitude. These three stars appear nearly in a straight line. The star α Aquilæ is nearly of the same colour as Antares.

FOMALHAUT.

S. E. from α Aquilæ, at the distance of 60°, is the star Fomalhaut, which is a bright star of high southern declination, its altitude in northern latitudes being small, never exceeding 20° in the latitude of 40° N. This star bears nearly south from the star α Pegasi, distant 45 degrees. A line drawn from the pointers, through the northern polar star, and continued to the opposite meridian, will pass very near to α Pegasi and Fomalhaut.

To find the true distance.

	° '	Col. 1st.		Col. 2d.			° ' "
App. Dist.	47 34	Sine	9.8681	same	9.8681	App. Dist. less 2° = 45°	33 48
✱ App. Alt.	50 31	2 Rem. 33° 55′ Co-se	0.2534	same	0.2534	Table XVII.	59 14
☽ App. Alt.	70 47	1 Rem. 36 52 Sec.	0.0969	1-2 Sum 84° 26′ Sec.	1.0132	Table XIX.†	42 08
		Table XVII. log.	1.8676	Table XIX. log.*	.2269	Cor. 1.	1 29
Sum	168 52					Cor. 2.	7 50
		1 Cor. 1′ 29″ P. L.	2.0860	2 Cor. 7′ 50″ P. L.	1.3616	Table XX.	20
1-2 Sum	84 26						
App. Dist.	47 34					True distance	47 24 49
1st. Rem.	36 52						
1-2 Sum	84 26						
✱ App. Alt.	50 31						
2d. Rem.	33 55						

To find the longitude.

		° ′ ″	
True distance		47 24 49	
Dist. by N. A. at 3h.		46 56 11	
Difference		28 38	P. L. 7981
Dist. by N. A.	at 3h.	46 56 11	
	at 6h.	48 23 59	
Difference		1 27 48	P. L. 3118
		0 58 42	P. L. 4866
	add	3	
Time at Greenwich		3 58 42	
Time at ship		12 6	
Longitude in time		8 7 18 = 121° 49′ E. from Greenwich.	

EXAMPLE II.

Suppose that on the 20th September, 1820, sea account, at 7h. 23′ 45″, P. M. apparent time, in the longitude of 166° 30′ W. by account, the observed distance of the nearest limb of the moon from the star Antares was 81° 3′ 18″, the observed altitude of the star 12° 34′, and the observed altitude of the moon's lower limb 20° 26′. Required the true longitude?

Preparation.

Sea account Sept. 20, is by the N. A. Sept. 19d. 7h. 23′ 45″
Long. 166° 30′ W. in time 11 6

				✱ obs. alt.	12 34
		Reduced time Sept. 19	18 29 45	sub.	4
☽ S. D. Sept. 19, midn.	16 35	☽ hor. par. Sep. 19, midn.	60 47	✱ app. alt.	12 30
Sept. 20, noon	16 40	Sept. 20, noon	61 3	☽ obs. alt. L. L.	20 26
Difference	5	Difference	16	add	12
Table XI.	3	Table XI.	9	☽ App. Alt.	20 38
Sum	16 38	☽ hor. par.	60 56	Obs. Dist. ☽ ✱ N. L.	81 03 18
Aug. Table XV.	5			☽ S. D.	16 43
☽ S. D.	16 43			App. Dist. ☽ ✱	81 20 01

* This Log. = Log. Table XIX. 2260 + Log. Table C. 9 = 2269.

† This Corr. = Corr. Table XIX. 41′ 49″ + Corr. Table A. 13″ + Corr. Table B. 6″ = 42′ 08

To find the true distance.

	°	′						°	′	″
App. Dist.	81	20	Sine	9.9950	same	9.9950	App. Dist. less 2° = 79		20	06
✱ App. Alt.	12	30	2 Rem. 44° 44′ Co-se	0.1525	same	0.1525	Table XVII.		65	47
☽ App. Alt.	20	38	1 Rem. 24 06 Sec.	0.0396	1-2 Sum 57° 14′ Sec.	0.2666	Table XIX.†		5	09
			Table XVII. Log.	1.3194	Table XIX. Log.*	.1898	Cor. 1		5	38
Sum	114	28					Cor. 2		44	55
1-2 Sum	57	14	1 Cor. 5′ 38″ P. L.	1.5065	2 Cor. 44′ 55″ P. L.	6029	Table XX.			23
1 Rem.	24	6								
2 Rem.	44	44					True distance	81	11	51

To find the longitude.

	h. or °	m. or ′	s. or ″	
True distance	81	11	51	
Dist. by N. A. at 18h.	80	57	28	
Difference		14	23	P. L. 1.0974
Dist. by N. A. at 18h.	80	57	28	
at 21h.	82	50	17	
Difference	1	52	49	P. L. 2029
	0	22	57	P. L. 8945
Add	18			
Time at Greenwich	18	22	57	
Time at ship	7	23	45	
Longitude in time	10	59	12 = 164° 48′ W.	

EXAMPLE III.

Suppose on April 25th at 2h. A. M. sea account, in the longitude of 166° E. by account, the observed distance of the moon's farthest limb from Antares was 76° 32′ 15″, the observed altitude of the star 23° 34′, the observed altitude of the moon's lower limb 17° 59′. Required the true longitude ?

Preparation.

	h.	m.
Sea account April 25, or by N. A. April 24th	14h.	0′
Long. 166° E.	11	4
Reduced time April 24th	2	56

	′	″
☽'s S. D. April 24, noon	14′	51″
midn.	14	53
Difference		2
Table XI.		0
Sum	14	51
Aug. Tab. XV.		5
Sub. ☽ S. D.	14	56

	′	″
☽'s Hor. Par. noon	54′	23″
mid.	54	31
Difference		8
Table XI.		2
☽ Hor. Par.	54	25

	°	′	″
✱ Obs. Alt.	23°	34′	
sub.		4	
✱ App. Alt.	23	30	
☽ Obs. Alt. L.L.	17	59	
add		12	
☽ App. Alt.	18	11	
Obs. Dist.	76°	32′	15″
Sub. ☽ S. D.		14	56
App. Dist.	76	17	59

To find the true distance.

	°	′	Col. 1st.		Col. 2d.			°	′	″
App. Dist.	76	17	Sine	9.9874	same	9.9874	App. Dist. less 2° = 74		17	16
✱ Ap. Alt.	23	30	2 Rem. 35° 29′ Co-se.	0.2362	same	0.2362	Table XVII.		57	59
☽ Ap. Alt.	18	11	1 Rem. 17° 18′ Sec.	0.0201	1-2 sum 58° 55′ Sec.	0.2878	Table XIX.§		10	51
			Table XVII. log.	1.5794	Table XIX. log.‡	2432	1 Cor.		2	42
Sum	117	50					2 Cor.		31	40
			1 Cor. 2′ 42″ P. L.	1.8231	2 Cor. 31′ 40″ P. L.	0.7547	Table XX.			25
1-2 Sum	58	55								
1 Rem.	17	18					True distance	76	00	45
2 Rem.	36	29								

* Table XIX. 1893 + Corr. Table C. 5 = 1898.

† Table XIX. 5′ 5″ + Corr. Table A. 2″ + Corr. Table B. 2″ = 5′ 9″.

‡ Table XIX. 2426 + Corr. Tab. C. 6 = 2432.

§ Table XIX. 10′ 19″ + Corr. Tab. A. 32″ + Corr. Tab. B. 0″ = 10′ 51″.

To find the true longitude.

True distance	76° 00′ 45″				
By N. A. distance at 3h.	76 00 57	Difference 0° 0′ 12″	P. L.	2.9542
6h.	74 30 58	Difference 1 29 59	P. L.	3011
		0h. 0′ 24″	P. L.	2.6531
	add	3		
Time at Greenwich		3 0 24		
Time at Ship		14		
Difference is long. in time		10 59 36=164° 54′ E. from Greenwich.		

EXAMPLE IV.

Suppose that on the 31st October, sea account, at about 1h. P. M. in the longitude of 75° W. by account, the following observations of the sun and moon were taken. Required the true longitude?

Preparation.

Time per watch.	Observed distance. ☉ ☾ N. L.	Observed Alt. ☉ L. L.	Observed Alt. ☽ L. L.
0h. 58′ 5″	68° 43′ 49″	45° 57′	17° 18′
0 59 8	43 18	52	17 9
1 0 10	42 47	48	16 59
1 1 4	42 20	44	16 48
1 1 53	41 56	39	16 36
5) 5 0 20	14 10	240	84 50
1 0 4	68 42 50	45 48	16 58
	☉ S.D. 16 9		
App. time	☽ S.D. 14 53	add 12	add 12
	69 13 52	46 0	17 10
	App. Dist.	App. Alt. ☉	App. Alt. ☽

Sea account 31 Oct. or N. A. Oct. 30d.	1h. 0′ 4″		
Long. 75° W.	5		
Reduced time Oct. . .	30d. 6h. nearly.		

☽ S. D. Oct. 30, noon	14′ 50″	☽ Hor. Par. Oct. 30, noon	54′ 21″
midnight	14 48	midn.	54 13
Difference	2	Difference	8
Table XI.	1	Table XI.	4
	14 49	☽ Hor. Par.	54 17
Aug. Table XV.	4		
☽ S.D.	14 53		

To find the true distance.

	°	′						°	′	″
App. Dist.	69	14	Sine	9.9708	same	9.9708	App. Dist. less 2°=	67	13	52
☉ Ap. Alt.	46	0	2 Rem. 20° 12′ Co-s	0.4618	same	0.4618	Table XVIII.		59	11
☽ Ap. Alt.	17	10	1 Rem. 3 2 Sec.	0.0006	1-2 Sum 66 12 Sec.	0.3941	Table XIX.†		10	52
			Table XVIII. log.	1.8848	Table XIX. log.*	2457	1 Cor.			52
Sum	132	24					2 Cor.		15	14
1-2 Sum	66	12	1 Cor. 52″ P.L.	2.3180	2 Cor. 15′ 14″ P. L.	1.0724	Table XX.			22
1 Rem.	3	2								
2 Rem.	20	12					True distance	68	40	23

* This Log.=Log. Tab. XIX. 2454 + Cor. Tab. C. 3=2457.

† This Corr.=Corr. Tab. XIX. 10′ 12″ + Corr. Tab. A. 40″ + Corr. Tab. B. 0″=10′ 52″.

To find the true longitude.

True distance	68°	40	23						
By N. A. Dist. at 6h.	68	40	29	Difference	0°	0	6″	P. L.	3.2553
By N. A. Dist. at 9h.	67	19	11	Difference	1	21	18	P. L.	3452
					0h.	0	13	P. L.	2.9101
				add	6				
				Time at Greenwich	6	0	13		
				Time at Ship	1	0	4		
				Difference is long. in time	5	0	9=75° 2 W. from Greenwich.		

EXAMPLE V.

Suppose that on the 5th May, 1820, sea account, at about 4h. 4′ P. M. in the latitude of 30° 1′ S. and in the longitude of 1° E. by account, the following observations of the Sun or Moon were taken. Required the true longitude?

Preparation.

	Observed Dist. ☉ ☾ N. L.			Observed Alt. ☉ L. L.		Observed Alt. ☽'s U. L.	
	101°	42	35	14°	53′	41°	58′
		41	30	15	21		34
		40	22	15	49		4
Sum:	3)	124	27	46	3		36
Mean	101	41	29	15	21	41	32
Index error		—	3		— 3	+	8
Cor. Index error	101	41	26	15	18	41	40
	☉ S. D.	15	52	add	12	sub.	20
	☽ S. D.	16	14				
	102	13	32	15	30	41	20
	App. Dist.			☉ App. Alt.		☽ App. Alt.	

Sea account, May 5, or N. A. May 4d.	4h.	4		
Longitude 1° E.		4		
		May 4d. 4h.		

Reduced time					
☽ S. D. May 4, noon	16′	3″	☽ Hor. Par. noon	58′	48″
midnight	16	6	midnight	58	58
Difference		3	Difference . . .		10
Table XL		1	Table XL . . .		3
	16	4	☽ Hor. Par. . . .	58	51
Aug. Table XV.		10			
☽ S. D.	16	14			

To find the true distance.

	°	′						°	′	″
App. Dist.	102	14	Sum	9.9660	same	9.9900	Ap. Dis. less 2=100		13	32
☉ App. Alt.	15	30	2 Rem. 64° 2′ Co-se.	0.0462	same	0.0462	Table XVIII.		56	45
☽ App. Alt.	41	20	1 Rem. 22 42 Sec.	0.0350	1-2 Sum 79° 32′ Sec.	0.7407	Table XIX.		16	35
			Table XVIII. log.	1.4207	Table XIX. log.	1951	1st. Cor.		5	48
Sum	159	4					2d. Cor.		19	12
1-2 Sum	79	32	1 Cor. 5′ 48″ P. L.	1.4979	2 Cor. 19′ 12″ P. L.	.9720	Table XX.			16
1st. Rem.	22	42					True distance	101	58	5
2d. Rem.	64	2								

To find the apparent time and true longitude.

⊙ Correct Altitude*	15°	27′		
Lat. of Ship	30	1	Secant	0.06254
Polar distance†	106	4	Co-secant	0.01730
Sum	151	32		
Half Sum	75	46	Co-sine	9.39071
Half Sum—Altitude	60	19	Sine	9.93891
		Sum		2)19.40946
Apparent time 4h. 3′ 32″			Sine	9.70473

True distance	101°	52′	3″		
By N. A. dist. at 3h.	102	25	6		
Difference		33	3	P. L.	7361
By N. A. dist. at 3h.	102	25	6		
6h.	100	47	39		
Difference	1	37	27	P. L.	2665
	1h.	1′	3″	P. L.	4696
add	3				
Time at Greenwich	4	1	3		
Time at Ship	4	3	32		
Longitude in time		2	29=0° 37′ E. from Greenwich.		

EXAMPLE VI.

Suppose that on the 8th of February, 1820, sea account, at about 8h. 36′ A. M. in the longitude of 21° W. from Greenwich by account, six distances of the sun and moon's nearest limbs were observed by a circle of reflection to be 464° 10′ 12″ the corresponding times and altitudes being as in the following Table. Required the true longitude?

Preparation.

Apparent time per watch, A. M.	Observed distance ⊙ ☾ N. L.	Observed Alt. ⊙ L. L.	Observed Alt. ☽ U. L.
8h. 33′ 24″	Sum of the dis-	34° 1′	61° 47′
34 36	tances taken	34 13	61 35
35 18	from the cir-	34 21	61 27
36 36	cle at the end	34 31	61 17
37 4	of the obser-	34 39	61 9
39 2	vations.	35 3	60 45
6) 36 0	464° 10′ 12″	206 48	368 0
8 36 0	77 21 42	34 28	61 20
App. time	⊙ S. D. 16 14	add 12	sub. 20
	☽ S. D. 15 56		
	77 53 52	34 40	61 0
	App. Dist.	⊙ App. Alt.	☽ App. Alt.

Feb. 8, sea account, or by N. A.	Feb.	7d.	20h. 36′
Long. 21° W			1 24
Reduced time	Feb.	7d.	22h.

☽'s S. D. Feb. 7, midnight	15′ 36″
Feb. 8, noon	15 43
Difference	7
Table XI.	6
	15 42
Aug. Tab. XV.	14
☽'s S. D.	15 56

☽'s Hor Par. Feb. 7, midnight	57′ 9″
Feb. 8, noon	57 37
Difference	28
Table XI.	23
☽'s Hor. Par.	57 32

To find the true distance.

	°	′				
App. Dist.	77	54	Sine	9.9902	same	9.9902
⊙ Ap. Alt.	34	40	2 Rem. 52° 7′ Co-sc	0.1028	same	0.1028
☽ Ap. Alt.	61	0	1 Rem. 8 53 Sec.	0.0052	1-2 sum 86° 47′ Sec.	1.2509
			Tab. XVIII. Log.	1.7702	Table XIX. Log‡.	2025
Sum	173	34				
1-2 Sum	86	47	1 Cor. 2′ 26″ P. L.	1.8684	2 Cor. 5′ 7″ P. L.	1.5464
1st. Rem.	8	53				
2d. Rem.	52	7				

	°	′	″
Ap. Dist. less 2=75		53	52
Table XVIII.		58	44
Table XIX§.		32	20
1st. Cor.		2	26
2d. Cor.		5	7
Table XX.			18
True distance	77	32	47

* The correct altitude is found by subtracting the refraction 3′ from the apparent altitude 15° 30′.

† The Polar Distance is found by adding the Declination 16° 4′ N. (corresponding to the reduced time) to 90°.

‡ This log.=Log. Tab. XIX. 2016 + Log. Tab. C. 9=2025.

§ This Corr.=Corr. Table XIX. 32′ 7″ + Corr. Tab. A. 13″ + Corr. Tab. B. 0″=32′ 20″.

EXAMPLE—*(the same as Example* I. *preceding.)*

Suppose the apparent distance of the centre of the moon from the star Aldebaran was 47° 33′ 48″, the apparent altitude of the star 50° 31′, the apparent altitude of the moon's centre 70° 47′, and the proportional logarithm of the moon's horizontal parallax 5199. Required the true distance of the moon from the star?

	90° 0′		90° 0′	Hor. Par. P. Log.	10.5199	
☽ App. Alt.	70 47	✱ Ap. Alt.	50 31	☽ Z. D. 19° 13′ Sine	9.5174	✱ Refrac. 47″
☽ Zen. Dist.	19 13	✱ Zen. Dist.	39 29	17′ 54″ P. L.	1.0025	

☽ Refraction	20
Cor. ☽ Alt.	17 34

App. Dist.	47° 34′	Constant log.	9.6990		
☽ Zen. Dist.	19 13	1-2 Sum 53° 8′ Cosec.	10.0969		
✱ Zen. Dist.	39 29	Dist. 47 34 Sine	9.8681		
Sum	106 16	Reserved Log.	9.6640	Reserved Log.	9.6640
1-2 Sum	53 8	✱ Zen. Dist. 39° 29′ Sine	9.8034	☽ Zen. Dist. 19° 13′ Sine	9.5174
☽ Zen. Dist.	19 13	1 Rem. 33 55 Co-sec.	0.2534	2d. Rem. 13 39 Co-sec.	0.6271
1st. Rem.	33 55	✱ Cor. 0′ 47″ P. L.	2.3613	☽ Cor. 17′ 34″ P. L.	1.0106
Half sum	53 8	1 Cor. 1 29 P. L.	2.0821	2d. Cor. 27 18 P. L.	0.8191
✱ Zen. Dist.	39 29				
2d. Rem.	13 39				

Apparent distance		47°	33′	48″
Add {	First Correction		1	29
	Cor. ☽ Alt.		17	34
Sub. {	2d. Cor. 27′ 18″ }	47	52	51
	Cor. ✱ Alt. 47 }		28	5
Corrected distance		47	24	46
Correction Table XX.				1
True distance		47	24	47 differing 2″ from the former method.

We shall now give a third method of correcting the apparent distance, being an improvement on Witchell's method, which was published in the former edition of this work. This improvement was made in consequence of a suggestion from a gentleman eminently distinguished for his mathematical acquirements;* that, by a small variation in the calculation, the number of cases might be lessened: and, upon examination, it was found that by making other alterations, the number of cases might be farther decreased, and the manner of applying the corrections rendered more simple. The method thus improved is as follows.

Third method of finding the true distance of the Moon from the Sun or Star.

From the Sun's refraction (Table XII.) take his parallax in altitude (Table XIV.) the remainder will be the correction of the sun's altitude.

The Star's refraction is the correction of its altitude.

From the proportional logarithm of the moon's horizontal parallax, increasing the index by 10, take the co-sine of the moon's apparent altitude (Table XXVII.) the remainder will be the proportional logarithm of the moon's parallax in altitude; from which, subtracting the moon's refraction (Table XII.) the remainder will be the correction of the moon's altitude.†

1. Add together the apparent altitudes of the moon and sun (or star) and take the half sum, subtract the lesser altitude from the greater, and take the half difference; then add together

The tangent of the half sum,

The co-tangent of the half difference,

The tangent of half the apparent distance.

The sum rejecting 20 in the index will be the tangent of the angle A, which must be sought for in Table XXVII. and taken out less than 90° when the sun's altitude is less than the moon's, otherwise greater than 90°.‡ The *difference* of the angle A,

* The late Chief Justice Parsons.

† These corrections may be found by Tables XVII. XVIII. XIX. as was shown in the note to the second method, page 160.

‡ Every co-tangent in Table XXVII. corresponds to two angles, one greater than 90°, the other less

BY LOGARITHMS.

To find the angle CBD.

By Theo. IV. Trig.

Divide the triangle BCD into two right-angled triangles by means of the perpendicular CA, and bisect BD in a, then

As the base BD 400 ar. co.		7.39794
Is to the sum of BC. CD,	750.7	2.87547
So is diff. of BC, CD,	150.7	2.17811
To twice A a	282.8	2.45152
Half or A a	141.4	
½ BD=Ba=	200	
Diff. is BA	58.6	

Then in the triangle ACB.

As hypot. DC 300	2 47712
Is to radius 90°	10.00000
So is AB 58.6	1.76790
To co-sine CBD 78° 44′	9.29078

By Theo. V. Trig.

CD=450.7		
BD=400	Log. ar. co.	7.39794
EC=300	Log. ar. co.	7.52288
Sum 1150.7		
½ Sum 575 35	Log.	2.75993
½ sum less CD 124.65	Log.	2.09569
	Sum	19.77644
Half sum 39° 22′	Co-sine	9.88822
2		

Doubled is 78 44=Angle CBD. Having found this angle, we may find either of the others thus,

To find the angle CDB.

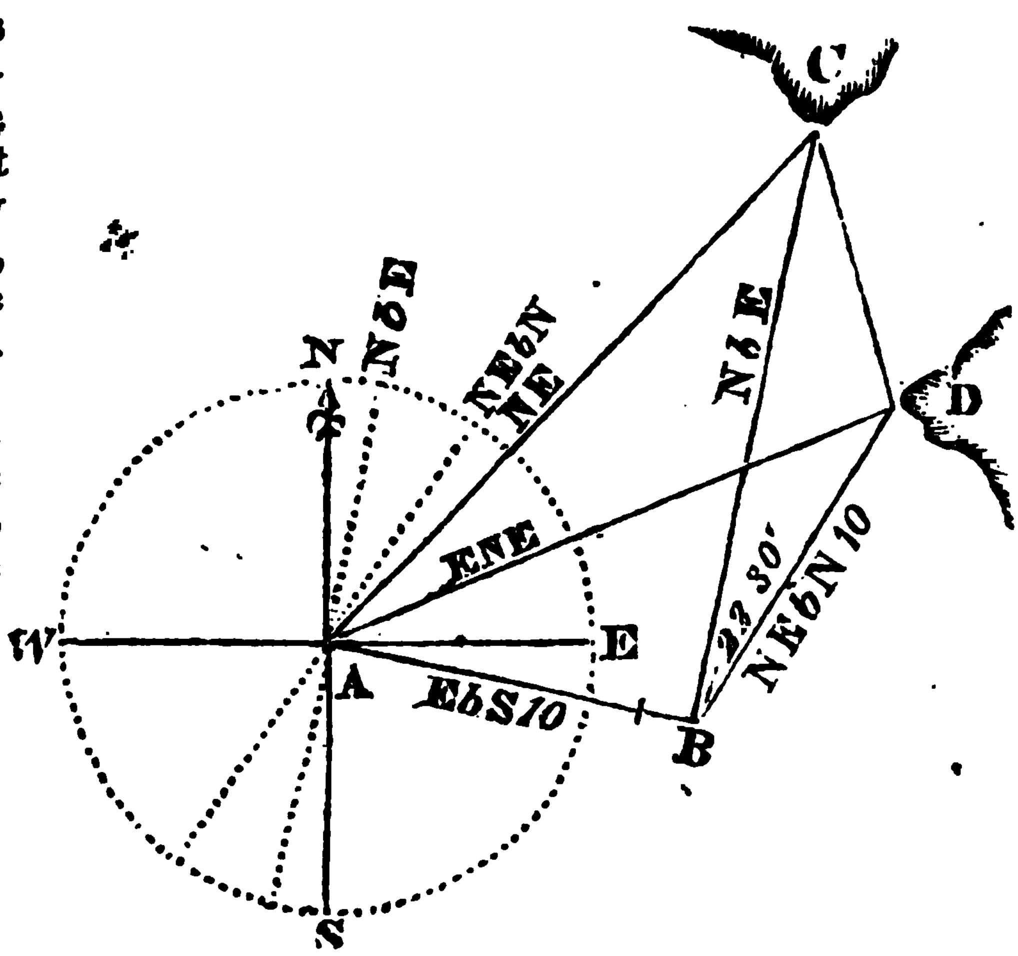
As CD 450.7 ar. co.	7 34611
Is to sine CBD 78° 44′	9.99155
So is BC 300	2 47712
To sine CDB 40° 45′	9.81478

As the angle CBD is 78° 44′ or 7 points nearly, and the course from B to D is E. by N. the course from B to C must be north. The course from D to B being W. by S. or W 11° 15′ S. and the angle BDC=40° 45′ the bearing of C from D must be W. 29° 30′ N because 40° 45′—11° 15′=29° 30′.

PROBLEM VI.

Coasting along shore, I saw two headlands, the first bore from me N. E. the second E. N. E.—after sailing E. by S. 10 miles, the first bore N. by E. and the second N. E. by N.—required the bearing of the two headlands from each other, and their distance?

Draw the compass NESW, and let its centre A represent the place of the ship at the first station, draw the E. by S. line AB=10 miles, and B will be the place of the ship at the second station; draw the N. E. line AC, and the E.N.E. line AD; through the point B draw the lines BC, BD parallel to the N. by E. and N. E. by N. lines, and the points C and D where they intersect the lines drawn from A to the same headlands will be the points representing them respectively; join the



points C and D;—then will CD be the distance of the two headlands, and a line drawn through A parallel to CD will represent the bearing of those places from each other on the compass.

BY LOGARITHMS.

In the triangle ABC, we have all the angles and the side AB to find BC. For the bearings of B and C from A are E. by S. and N E. the difference being 5 points=BAC; and the bearings of B and A from C, are S. by W. and S. W. the difference being 3 points equal to the angle ACB.

To find the side BC.

As sine of ACB 3 pts. ar. co.	0.25526
Is to the side AB 10	1.00000
So is sine angle BAC 5 pts.	9.91985
To BC 14.97	1.17511

In the triangle ABD, we have all the angles and the side AB to find BD. For the bearings of B and A from D, are S. W. by S. and W. S. W. the difference being 3 points=BDA; and the bearings of B and D from A, are E. by S. and E.N.E. the difference being also 3 points, equal to the angle BAD; therefore the angle BAD=BDA, and (by art. 39 *Geom.*) BD=AB=10 miles. If these angles had not been equal, we might have calculated the side BD in the same manner as BC.

SURVEYING. Plate X

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1821.

anchor, and the direction is to be represented by an arrow. Put in a compass and a scale of miles or leagues such as the vessel's run was laid down by : add the name of the place, and the latitude and longitude as true as can be obtained.

If there are shoals or sands on the coast, let them be taken in a boat, sailing round them, keeping account of the courses, distances, and soundings.* But to put them in the draught, the observer in the boat must take the bearings of two points on the coast, (the bearings of which have been taken from the ship) from some part of each sand or shoal, so sailed round; or, the bearing of the boat at some part of the shoal, or of some beacon in that place, must be taken by the ship at each of the stations where the bearings of the shore were taken from the ship; for by either of these means, one point of the sand being obtained, the rest of it can be laid down from the observations taken in the boat. Rocky shoals may be marked on the chart, as in Plate XI. fig. 11, and sand banks as in fig. 10.

If the coast to be drawn is a bay or harbour winding in such manner that all its parts cannot be seen at two stations, let as many bases or lines be run and measured exactly as may be found necessary, observing that the several distances run should join to one another, in the nature of a traverse; that each new set of objects, or points observed, should be taken from two stations at the ends of a known distance, and that the objects whose bearings are taken do not so much extend beyond the limits of the base as to make angles with it less than about ¼ or ⅓ of a point, but rather reserve such objects for the next measured base line: for when lines lie very obliquely to one another, their intersections are not easily ascertained.

If any particular parts of the harbour cannot be conveniently seen from either of the stations, take the boat into those places, and having well examined them, make sketches thereof, estimating the lengths and breadths of the several inlets, either by the rowing or sailing of the boat, take as many bearings, soundings, and other notes, as may be thought necessary; then annex these particular views in their proper places, in the general draught.

If there are any dangerous sands or rocks, besides inserting them in their proper places, you must see if there be any two objects ashore (such as a church, mill, house, noted cliff, &c.) which appear in the same right line when on the shoal: and these objects must be noted on your chart. If none can be found, you must take the bearings of some remarkable points, and note them on your chart; by which means it will be known how to avoid the danger.

It should be remarked in the draught the kind of bottom obtained in sounding, whether mud, sand, shells, coral, rocky ground, &c.: and where there is good anchorage draw the figure of an anchor. Also, if there is any particular channel more convenient than another, it is to be pointed out by lines drawn to its entrance from two or more noted marks ashore.

The positions of objects taken by a magnetic compass being liable to great uncertainties, as is well known to those who have had any experience, especially at sea; it has therefore been recommended to observe only the bearings of the station lines by the compass, and then measure the angles which the other objects make with these lines, by a quadrant or sextant, which for this purpose must be held in an horizontal position.

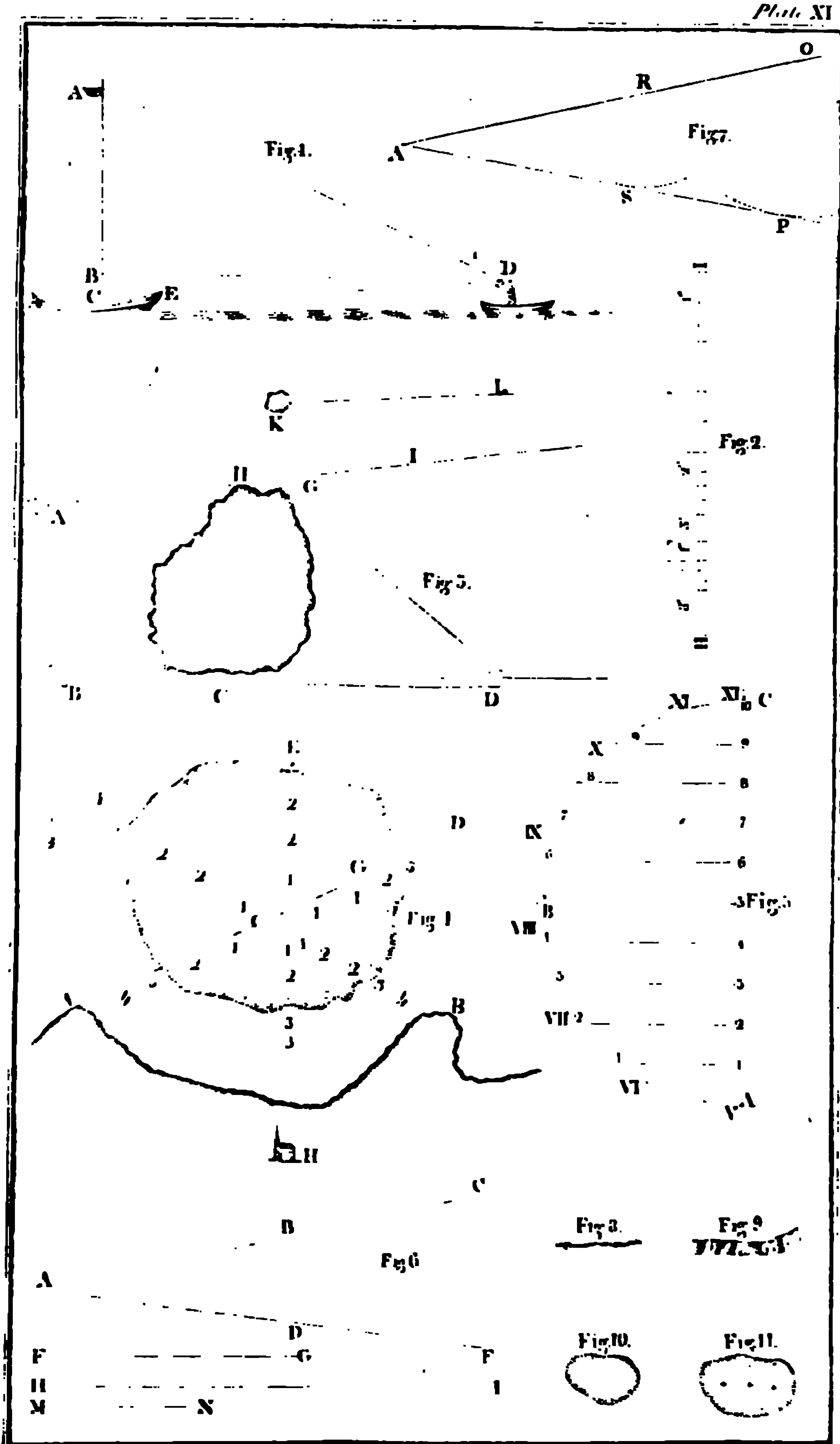
EXAMPLE I. (See fig. 1, Plate X.)

Suppose a ship at A observes the bearings of the most remarkable point of a bay, C, D, E, F, G, H, and I, and sails S. 64° E. 1½ miles to B; at B

---

* It is difficult to ascertain correctly the courses and distances sailed by the boat, on account of the currents and other causes. This inconvenience may be obviated if the ship be at anchor, and not far from the boat, by observing in the boat the bearing of the ship by compass, and by measuring, with a quadrant, the angle contained between the top-gallant-mast head, and that part of the ship which is at the same height as the eye of the observer; for by this angle the distance of the boat from the ship may be determined, as will be explained in this work.

Plate XI



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done) bring the object in a range with another remarkable object, and by this means you will avoid the error which might arise from the use of a compass.

For an example of this method, suppose that a survey of the small islands A, B, K, (Plate XI. fig. 3) and the large one CHG had been taken and plotted off as in the figure. Then soundings may be taken in the direction BCD by bringing the small island B in a range with the southern part of the great island, and measuring the angle CDG formed by the extremes of the great island; or by keeping the small island A to range with the northern part of the great island, and measuring the angle HIK formed by the northern extreme of that island, and the small island K; or by running in the direction KL so as to keep the island K to bear W. ¼ S. and measuring the angle formed by that island and the northern extreme of the great island, &c.

The method I have generally used for plotting off such angles is by means of a sector; and as that instrument is more easily procured than others better adapted to the purpose, I shall explain the method by showing how the angle CDG, measured as above, may be plotted off so as to determine the point D where that angular distance was observed. To do this, you must draw the line DC, and open the sector till the two legs form with each other an angle equal to the observed angle CDG, then slide one leg of the sector on the line DC till the other leg touches the northern extreme of the island at the point G, and the point directly under the centre of the joint of the sector will be the point of observation; as this point cannot be exactly marked on account of the size of the joint of the instrument, you may mark with a pencil on the line DC the two points where the circumference of the joint touches that line, and note the sounding in the middle between those two marks.

If a quadrant of a circle be described on a piece of paper, with a radius equal in length to one of the legs of the sector, and then divided into 90°, the sector may, by means of that quadrant, be opened to any angle in a very expeditious manner.

This method of obtaining distances when sounding, I have frequently used with success.

To reduce soundings taken at any time of the tide to low water.

The soundings at low water are always to be marked on a chart, and if they are taken at any other time of the tide, a proper allowance must be made to reduce them to low water. This allowance may be made if the whole vertical rise of the tide from low to high water be known, and the time of high and low water, as in the following example.

Suppose the vertical rise of tide from low to high water, to be 10 feet, the time of low water 5h. A. M. and the time of high water 11h. 30m. A. M.; required the allowance to be made on an observation taken at 8 A. M.?

Drawn the line AC (Plate XI. fig. 5) and make it equal to the whole rise of the tide 10 feet, taken from any scale of equal parts, and divide the line into equal parts representing feet, at the points 1, 2, 3, &c. to 10, the mark 10 (corresponding to the whole rise of the tide) being at the point C, and through these points draw lines 11, 22, 33, &c. perpendicular to AC, to meet the circumference of a circle drawn on the diameter AC. Divide the semi-circumference ABC of that circle into a number of equal parts representing the number of hours elapsed from low to high water,* which in this case is 6½ h. the hour of low water being marked at A, and that of high water at C, the intermediate hours being marked in succession as in the figure;

* This division of the semi-circle may be made by means of a line of chords. The number of degrees corresponding to one hour being found by saying, as the whole elapsed time from low to high water (6½ hours) is to 180° so is one hour to the arch corresponding to 1 hour 27° 42′, which being taken from a line of chords and laid off from 5h. will reach to 6h. &c.

east and west, the land is to the northward: therefore as the winds on this coast are generally between the south and W. S. W. they are obliged to steer S. S. E. or south, and with these courses they run off the shore; but in so doing they always find the wind more and more contrary; so that, though when near the shore they can lie south; at a great distance they can make no better than S. E. and afterwards E. S. E. with which courses they generally fetch the island of St Thomas or Cape Lopez, where finding the winds to the eastward of the south, they sail westerly with it, till coming to the latitude of 4 degrees south, they find the S. E. wind blowing perpetually.

On account of these general winds, all bound from Europe to the West Indies, or to the southern states of America, consider it most advantageous to get as soon as they can to the southward, that so they may be certain of a fair and fresh gale, to run before it to the westward. For the same reason, those bound from America to Europe endeavour to gain the latitude of 30 degrees, where they first find the wind begin to be variable, though the most ordinary winds in the North Atlantic Ocean come between the south and west.

And for the same reasons those bound to India from America run to the eastward in the variable winds, so as to be in the longitude of 35° or 36° W. when in the latitude of 30° N. From thence they steer south-easterly towards the Cape de Verds, passing 4° or 5° to the westward of them, unless they wish to stop for supplies, or to correct their longitude. Being then in the common route of the European Indiamen, they steer south-easterly to cross the equator between the longitude of 18° W. and 25° W. where meeting the S. E. trade winds, they must brace up and sail upon a wind till they get through them, and come into the variable winds, where they may steer to the eastward. Near the equator, the trade wind is generally stronger to the westward than to the eastward; and were it not for the fear of falling in with the Brazil coast, a ship might cross the line farther to the westward than what we have recommended above. Ships homeward bound, from the Cape of Good Hope towards America may deviate a little to the westward of their straight course, and cross the equator in about 30° W. longitude, in order to take advantage of this fresher trade wind.

Between the southern latitudes of 10° and 30° in the Indian Ocean, the general trade wind about S. E. is found to blow all the year round, in the same manner as in the like latitudes in the south Atlantic Ocean; and during the six months, from May to November, these winds reach to within 2 degrees of the equator: but during the other six months, from November to May, a N. W. wind, called the *N.W. monsoon*, blows in the tract lying between the 3d. and 10th. degrees of south latitude, in the meridian of the north end of Madagascar, and between the 2d. and 12th. degrees of south latitude, near the longitude of Sumatra and Java.

In the tract between Sumatra and the African coast, and from 3° of south latitude quite northward to the Asiatic coast, including the Arabian Sea and the Bay of Bengal, the monsoons blow from October to April on the N. E. and from April to October on the S. W. In the former half year, the wind is more steady and gentle, and the weather clearer than in the latter six months. In the Red Sea the winds blow nearly nine months of the year from the southward, that is, from August to May, and the rest of the year from the N. and N. N. W. with land and sea breezes. In the Gulf of Persia the N. W. wind blows from October to July, and about three months from the opposite quarter. These winds being often interrupted by gales from the S. W. and by land breezes.

Between the island of Madagascar and the coast of Africa, and thence northward as far as the equator, there is a tract, wherein, from April to October, there is generally a S. S. W. wind, and a contrary wind the rest of the year, with regular land and sea breezes on both coasts.

To the eastward of Sumatra and Malacca, on the north of the equator,

and along the coasts of Cambodia and China, quite through the Phillippines as far as Japan, the monsoons blow N. E. and S. W. the N. E. setting in about October or November, and the S. W. about May.

Between Sumatra and Java to the west, and New-Guinea to the east, there are regular monsoons. The N. W. monsoon blows from October to April, the S. E. monsoon the rest of the year.

The monsoons do not shift suddenly from one point of the compass to the opposite; in some places, the time of the change is attended with calms, in others by variable winds; and it often happens, on the shores of Coromandel and China, towards the end of the monsoons, that there are most violent storms, called Tuffons, greatly resembling the hurricanes in the West Indies, wherein the wind is so vastly strong, that hardly any thing can resist its force; for this reason it is more dangerous to approach those shores at the time of the breaking up of the monsoon than at any other season of the year.

The *land* and *sea breezes* prevail principally between the tropics. The sea breeze generally sets in about ten in the forenoon, and continues till about five or six in the evening: at seven the land breeze begins, and continues till about eight in the morning. The cause of these winds is this:—during the day the sea is not so much heated by the sun as the land, nor so much cooled at night. Hence, in the day time, the cooler air from the sea will rush towards the land to supply the deficiency occasioned by the greater rarefaction of the air, and hence arises the sea breeze. In like manner, during the night, the air at land, being more cooled than that at sea, will therefore blow from the land towards the sea, and hence occasion a land breeze.

A *whirlwind* is a dangerous phenomenon caused by the adjacent air, rushing in from all parts towards a centre with great rapidity, and destroying every thing it passes over in its progressive motion. A *water spout* and whirlwind arise from the same cause, the latter being formed at land, is composed principally of air, but the former being formed at sea is composed of water.

It was first observed by Doctor Franklin that the N. E. storms on the coast of the United States of America frequently begin earlier in the southern states than in the northern. This he accounts for by supposing a great rarefaction of air in or near the gulph of Mexico; the air rising thence has its place supplied by the next more northern, and therefore denser and heavier air; a successive current is thus formed, to which the coast and inland mountains give a N. E. direction.

Experiments have been made by several persons to determine the velocity of the wind, by observing the space passed over by a cloud or any light substance, and by other methods; and it has been found that the velocity of the wind in a violent gale is about 50 or 60 miles per hour.

TIDES.

TIDE is a periodical motion of the water of the sea, by which it ebbs and flows twice a day. The *flow* continues about 6 hours, during which the water gradually rises till it arrives to its greatest height; then it begins to *ebb* or decrease, and continues to do so for about 6 more, till it has fallen to nearly its former level; then the flow begins as before. When the water has attained its greatest height it is said to be *high-water*, and when it is done falling it is called *low-water*.

The cause of the tides is the unequal attraction of the sun and moon upon different parts of the earth. For they attract the parts of the earth's surface nearest to them, with a greater force than they do its centre: and attract the centre more than they do the opposite surface. To restore this equilibrium the waters take a spheroidal figure, whose longer axis is directed

towards the attracting luminary. If the moon only acted upon the water, the time of high water would be when the moon was upon the meridian, above or below the horizon; or rather at an hour or two after, (because the moon continues to act with considerable force for some time after passing the meridian.) [illegible] that the moon passes the meridian about 49' later every day: of course, if she only acted on the tides, they would be retarded every day 49', and it would be high water at the same distance from her passing the meridian: and it is upon this principle that the time of high water is calculated in most books of navigation, although the time thus calculated will sometimes differ [illegible] from the truth, owing to the neglect of the disturbing force of the sun. The effect of the moon upon the tides is greater than that of the sun, notwithstanding the quantity of matter in the latter is vastly greater than in the former; but the sun, being at a much greater distance from the earth than the moon, attracts the different parts of the earth with nearly the same force; whereas the moon, being at a much less distance, attracts the different parts of the earth with very different forces. According to the latest observations the mean force of the sun for raising the tides is to the mean force of the moon as 1 to 2[illegible]. By the combined effect of these two forces, the tides [illegible] sooner when the moon is in her *first* and *third* quarters, and [illegible] second and fourth quarters, than they would do if caused [illegible]. The mean quantity of this acceleration [illegible] the use of which will be [illegible]

[illegible]

RULE.

Enter Table C. and take out the number which stands opposite to the year, and under the month for which the tide is to be calculated: this number added to the day of the month, will give the moon's age, rejecting 30 when the sum exceeds that number. Against her age found in the left hand column of Table D. is a number of hours and minutes in the adjoined column, which being added to the time of high water at the given place on the full and change days, will give the time of high water required, observing to reject 12h. 24m. or 24h. 48m. when the sum exceeds either of those times.

By this rule I shall work the two preceding examples.

EXAMPLE III.

Required the time of high water at Charleston (S. C.) March 17, 1820, in the afternoon, civil account?

In the table C, opposite 1820, and under March, stand 16, which, added to the day of the month 17, gives 33, and by subtracting 30, leaves 3, the moon's age: opposite 3 in Table D, is 1h. 46m. which added to 7h. 15m. the time of high water on the full and change days, gives 9h. 1m. for the time of high water; differing eleven minutes from the former method.

EXAMPLE IV.

Required the time of high water at Portland, (Mass.) May 23, 1820, in the afternoon, civil account?

In the Table C. opposite 1820, and under May, stand 18, which added to the day of the month 23, gives (by neglecting 30) the moon's age 11: opposite to this, in Table D, is 9h. 19m. which added to 10h. 45m. the time of high water on the full and change days, gives 20h. 4m. from which subtracting 12h. 24m. there remains 7h. 40m. for the time of full sea May 23, 1820; this differs 2 minutes from the former method.

In the third column of Table D is given the time of the moon's coming to the meridian, for every day of her age. thus, opposite 11 days stand 8h. 57m. which is the time of her coming to the meridian on that day. This table may be of some use when a Nautical Almanac cannot be procured: but being calculated upon the supposition that the moon moves uniformly in the equator, the table cannot be very accurate. The numbers in this Table are reckoned from noon to noon; thus, 1h. A. M. is denoted by 13h.; 2h. A. M. by 14h. &c.

The time of new moon is easily found, by subtracting the number taken from Table C from 30. Ex. Suppose it was required to find the time of new moon for May. 1820? By examining the table, we find the number corresponding to that time is 18; this subtracted from 30 leaves 12; therefore it will be new moon the 12th. May, 1820.

When the time of high water is known for any day of the moon's age, we may from thence find the time of high water on the full and change days, by the following

RULE.

Find the time of the moon's coming to the meridian of Greenwich, in the 6th. page of the Nautical Almanac: to this time apply the corrections taken from the tables A and B, (in the same manner as directed in the preceding rule for finding the time of high water) subtract this corrected time from the observed time of high water, and the remainder will be the time of high water, on the change and full days.

NOTE. If the time to be subtracted be greater than the observed time of full sea, you must increase the latter by 12h. 24m. or by 24h. 48m. nearly.

EXAMPLE.

Suppose that on the 17th. March, 1820, the time of high water at Charles-

day, which take as a course in Table II. and seek for the departure in the column of Diff. Lat. then will the distance corresponding be the difference of longitude, of the same name as the departure.

5. If the longitude in yesterday be of the same name as the difference of longitude, add them together; but if of different names, take their difference; the sum or remainder will be the long. in, of the same name as the greater.

6. If a lunar observation were taken at any time of the day, you must find, by the above method, the difference of longitude made since taking the observation for regulating the watch, and thence the longitude in at noon by that observation, and enter it in the Journal as the longitude by observation.

7. Find on a general chart the spot corresponding to the latitude and longitude by observation, and that place will represent the situation of the ship, whence the bearing and distance of the intended port may be found. The same may be obtained by middle latitude sailing, by inspection of Table II. thus: Find the middle latitude between the place of the ship and the proposed place, and seek for that latitude as a course in Table II. and find in the corresponding page of the Table, the difference of longitude (between the ship and the proposed place) in the distance column, opposite to which, in the latitude column, will be the departure. Seek in Table I. for this departure and the difference of latitude (between the ship and the proposed place) till they are found to agree, corresponding thereto will be the bearing and distance required. If the magnetic bearing be required, the variation must be allowed on the true bearing; to the right hand if the variation is westerly, or to the left hand if easterly.

We shall now proceed to exemplify the above rules; first by a few examples of separate day's works, and then by a Journal from Boston to Madeira, kept in the usual form.

EXAMPLE III.

Suppose that at the end of the sea day, March 10, 1820, we were in the latitude of 43° 34′ N. and the longitude of 20° E. and have sailed till next noon as per log-board; required the latitude and longitude in, and the variation of the compass?

In calculating the variation from the above observation it is necessary to find the declination and latitude at the time of observation. The former at noon ending the sea-day, March 11, 1820, was 3° 37′ S. by Table IV. the correction for the long. 20° E. is +1′ 17″; and for the time from noon 4h. is +3′ 51″, therefore the whole correction is nearly 5′, which added to 3° 37′ gives the declination at the time of observation 3° 42′ S. consequently the polar distance 93° 42′. To find the latitude we must see by the log-board what courses and distances the ship has sailed from noon to the time of observation at 8 A. M. viz. W.S.W. 58 miles, and S. W. by W. 19 miles: the current setting in the same time N. E. 5 miles; these courses must be corrected for one point westerly variation, which is found to be nearly its value, by a rough calculation made with the latitude in the preceding noon; and by arranging these courses and distances in a traverse table we find that the difference of latitude made good at 8 A. M. is about 41 miles, consequently the latitude in at the time of observation is nearly 42° 53′ N. the observed altitude of the sun's L. L. is 18° 40′; the correction for dip and semi-diameter +12′, and the refraction by Table XII.— 3′ nearly, consequently the sun's correct altitude is 18° 49′. With these data, the true azimuth is calculated as in page 113.

Polar Dist.	93°	42′		
Latitude	42	53	Secant	0.13505
Altitude	18	49	Secant	0.02385
Sum	155	24		
½ sum	77	42	Co-sine	9.32844
Polar Dist.	93	42		
Remainder	16	0	Co-sine	9.98284
			Sum	19.47018
Half sum is log. co-sine	57°	5′		9.73509
		2		

True azimuth	N.	114	10	E.
Mag. azimuth	N.	125	19	E.
Variation				

The variation being allowed on all the courses, and on the set of the current, and the distances being summed up, the traverse table will be as adjoined: and the difference of latitude made good= 49.8 S. departure=67.5 W. Hence the course made good S. 53½° W. and distance=84 miles. And by subtracting the difference of latitude 50′ from latitude left 43° 34′, there remains the latitude in 42° 44′ N. Hence we have the middle latitude 43° 9′, with which and

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Polar Dist.	93	42		
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			Sum	19.47018

Half sum is log. co-sine 57° 5′ 9.73509

2

True azimuth	N.	114	10	E.
Mag. azimuth	N.	125	19	E.
Variation				

The variation being allowed on all the courses, and on the set of the current, and the distances being summed up, the traverse table will be as adjoined: and the difference of latitude made good= 49.8 S. departure=67.5 W. Hence the course made good S. 53¾° W. and distance=84 miles. And by subtracting the difference of latitude 50′ from latitude left 43° 34′, there remains the latitude in 42° 44′ N. Hence we have the middle latitude 43° 9′, with which and

EXAMPLE III.

Suppose that at the end of the sea day, March 10, 1820, we were in the latitude of 43° 34′ N. and the longitude of 20° E. and have sailed till next noon as per log-board; required the latitude and longitude in, and the variation of the compass?

In calculating the variation from the above observation it is necessary to find the declination and latitude at the time of observation. The former at noon ending the sea-day, March 11, 1820, was 3° 37′ S. by Table IV. the correction for the long. 20° E. is+1′ 17″; and for the time from noon 4h is+3′ 51″, therefore the whole correction is nearly 5′, which added to 3° 37′ gives the declination at the time of observation 3° 42′ S. consequently the polar distance 93° 42′. To find the latitude we must see by the log-board what courses and distances the ship has sailed from noon to the time of observation at 8 A. M. viz. W. S. W 58 miles, and S. W. by W. 19 miles; the current setting in the same time N. E. 5 miles; these courses must be corrected for one point westerly variation, which is found to be nearly its value, by a rough calculation made with the latitude in the preceding noon; and by arranging these courses and distances in a traverse table we find that the difference of latitude made good at 8 A. M. is about 41 miles, consequently the latitude in at the time of observation is nearly 42° 53′ N. the observed altitude of the sun's L. L. is 18° 40′; the correction for dip and semi-diameter+12′, and the refraction by Table XII.— 3′ nearly, consequently the sun's correct altitude is 18° 49′. With these data, the true azimuth is calculated as in page 113.

Polar Dist.	93°	42′		
Latitude	42	53	Secant	0.13505
Altitude	18	49	Secant	0.02385
Sum	155	24		
½ sum	77	42	Co-sine	9.32844
Polar Dist.	93	42		
Remainder	16	0	Co-sine	[illegible]
			Sum	19.47012

Half sum is log. co-sine 57° 5′ 9.73509

2

True azimuth	N.	114	10	E.
Mag. azimuth	N.	125	19	E.
Variation				

The variation being allowed on all the courses, and on the set of the current, and the distances being summed up, the traverse table will be as adjoined: and the difference of latitude made good=49.8 S. departure=67.5 W. Hence the course made good S. 53¾° W. and distance=84 miles. And by subtracting the difference of latitude 50′ from latitude left 43° 34′, there remains the latitude in 42° 44′ N. Hence we have the middle latitude 43° 9′, with which and

JOURNAL

OF A VOYAGE FROM BOSTON TO MADEIRA.

Cape Cod bearing from the ship S. S. E. 1-4 E. distant 12 miles, is the same as if the ship had sailed from it 12 miles upon the opposite or N. N. W. 1-4 W. point of the compass, and allowing for the variation, it becomes N. W. by N. this and the distance 12 miles, are to be set in the traverse table as the first course and distance.

The ship sailed all day upon an E. by S. course by compass, which, by allowing the variation is E. 1-4 S. The whole distance sailed (or the sum of all the distances) is 101 miles. With these courses and distances, I find the corresponding differences of latitude and departures; and by subtracting the southing from the northing, and the westing from the easting, find that the difference of latitude made good is 5.0 N. and the departure 94.2 E. which correspond to a course of N. 86° 58' E. and distance 94 miles.

Lat. sailed from, or Cape Cod's lat.	42° 05' N.
Diff. of lat.	0 05 N.
Latitude in	42 10 N.
Sum of lats.	84 15
Middle latitude	42 7

Then with the middle latitude 42° as a course, I enter Table II. and against the departure 94.2 (or 94.4 which is the nearest tabular number) found in the latitude column, is 127 = the difference of longitude in the distance column.

Long. from, or Cape Cod's long.	70° 4' W.
Diff. Long.	2 7 E.
Long. in	67 57 W.

To find the bearing and distance of Funchal.

Latitude in	42° 10' N.	Mer. parts	2795	Long. in	67° 57' W.
Funchal's lat.	32 38 N.	Mer. parts	2073	Funchal's long.	17 5 W.
Diff. of lat.	9 32	Mer. diff. lat.	722	Diff. long.	50 52
	60				60
In miles	572			In miles	3052

With the merid. diff. of lat. 722 miles, and diff. of long. 3052 miles, the bearing is found to be S. 76° 41' E. and with this bearing taken as a course, and the proper difference of latitude 572 miles, the distance is found to be 3066 miles, by Case I. of Mercator's sailing.

H	K	F	Courses.	Winds.	L W	Remarks on board, Sunday, Mar. 26, 1820.
1	7		E. by S.	N. by E		Fresh gales and pleasant weather.
2	7					
3	7					Saw a number of fishing vessels to the
4	7					southward.
5	7					
6	7					
7	7		EbyS½S	N.N.E		At noon observed the altitude of
8	7					the sun's lower limb bearing
9	7					south 50° 26′N.
10	7					Add for semi-diameter, dip, &c. 0 12
11	7					The refraction being small is ne-
12	7					glected.
1	7		E. S. E.			Correct altitude 50 38
2	7					Subtract from 90 00
3	6	6				
4	6	6				⊙'s zenith distance 39 22 N.
5	6	4				⊙'s correct declination 2 21 N.
6	6	4				
7	6	4				Latitude by observation 41 43 N.
8	6	4				
9	6	6				
10	6	6				
11	6	5				
12	6	5				Variation ½ point westerly.

Course.	Dist.	Diff. Lat.	Dep	Lat. by D. R.	Lat. by Obs.	Diff. Long.	Long. in.	Bearing & Dist.
S 80° 15′ E	162	S. 27	E. 160	S. 41° 43′	N. 41° 43′	E. 3° 35′	W. 64° 22′	Funchal, 76° 24′ E. distance 2319 miles

The variation being allowed on each course, and the distances summed up, they will stand as in the adjoined traverse table; from hence, by means of Table I. I find the difference of latitude 27,5, and the departure 160.0, which corresponds to the course S. 80° 15′ E. and the distance 162 miles.

TRAVERSE TABLE.

Courses.	Dist.	N.	S.	E.	W.
E. ¼ S.	42		2.1	41.9	
E. ¾ S.	42		6.2	41.5	
E.S.E.¾E.	79		19.2	76.6	
		D.Lat.	27.5	160.0	Dep.

Yesterday's latitude	42° 10′ N
Diff. of latitude	27 S
Latitude in	41 43 N.
Sum of latitudes	83 53
Middle latitude	41 56

With the middle latitude 41° 56′ or 42° as a course. I enter Table II and seek for the departure 160.0 in the latitude column; the nearest number to which is 159.8 corresponding to the distance 215, which is therefore the difference of longitude, equal to 3° 35′ E.

Yesterday's long.	67 57 W.
Long. in	64 22 W.

To find the bearing and distance of Funchal.

Latitude in	41° 43′ N.	Mer. parts	2759	Longitude in	64° 22′ W.
Funchal's lat.	32 38 N.	Mer. parts	2073	Funchal's long.	17 5 W.
Diff. of lat.	9 5	M. D. lat.	686	Diff. of long.	47 17
	60				60
In miles	545			In miles	2837

By Case I. of Mercator's sailing, I find the bearing of Funchal to be S 76° 24′ E. and its distance 2319 miles.

When the sun was upon the meridian, the altitude of his lower limb was 50° 24′, to which add 12′ for the semidiameter, parallax, and the dip of the horizon; the refraction, (given in Table XII.) for this altitude being small, is neglected; hence the correct central altitude was 50° 36′ which subtracted from 90°, leaves the zenith distance 39° 24′ which must be called north, because the sun bore south when on the meridian; then in Table IV. I find the sun's declination at noon at Greenwich= 2° 17′ N. to this add the correction 4′. taken from Table V. corresponding to the ship's longitude; the sum is 2° 21′ N.=the correct declination; and since the declination and zenith distance are both north, I add them together, and the sum will be the latitude by observation=41° 43′ N. which agrees with the latitude by account.

TRAVERSE TABLE.					
Course.	Dist.	N.	S.	E.	W.
E.S.E. ½ E.	192	D. Lat.	46.7	186.2	Dep

The ship sailed all day upon the same course, which corrected for the variation, is E. S. E. ½ E. the whole distance sailed is 192 miles, and the difference of latitude is 47 miles.

	0°	47′	S.
Yesterday's latitude	41	43	N.
Latitude by D. R.	40	56	N.

Hence the latitude by account differs 10 miles from the latitude by observation; but it will not be necessary to correct the longitude on account of this error.

Latitude yesterday by obs.	41°	43′	N.
Latitude by obs. this day,	40	46	N.
Diff. of lat. by obs.		57	
Sum of latitudes	82	29	
Middle latitude	41	14	

With the middle latitude 41° 14′ as a course, and the departure 186,2 as difference of latitude, I find the corresponding distance 248, which is equal to the difference of longitude 4° 8′ E.

Yesterday's long.	64	22	W.
Long. in	60	14	W.

Note. As this journal is only designed to exemplify the rules of navigation, we have not endeavoured to give the true variation.

To find the bearing and distance of Funchal.

Latitude in	40°	46′	N.	Mer. parts	2683	Longitude in	60°	14′	W.
Funchal's lat.	32	38	N.	Mer. parts	2973	Funchal's long.	17	5	W.
Diff. of lat.	8	8		M. D. lat.	610	Diff. long.	43	9	
	60						60		
In miles	488					In miles	2589		

With the merid. diff. of lat. and diff. of long. the bearing is found to be S. 78° 40′ E. with that and the proper diff. of lat. the distance is found to be [illegible] miles,* by Case I. Mercator.

* If the course was calculated to seconds, and the meridional parts taken to one or two places of decimals, it would sometimes make a difference of a few miles in the calculated distance.

H	K.	F.	Courses.	Winds.	L W	Remarks on board, Tuesday, Mar. 28, 1820.
1	7		S E.by E.	N E by E	1	Fresh gales, with rain.
2	7					At 4 A. M. spoke the ship Franklin,
3	6	6				from Philadelphia, bound to Lisbon.
4	6	6				
5	6					
6	6					
7	5	4				
8	5	4				
9	5	6	S. E.	E. N. E.	1	At noon, observed mer. alt.
10	5	6				sun's L. L. 53° 52'
11	5	6				Add for semi-diameter, &c. 0 12
12	5	6				
1	5	5				Sun's correct altitude 54 4
2	5	3				Subtract from 90 00
3	5	5				
4	5	5				Sun's zenith distance 35 56 N.
5	6		S E.by S.	E.by N.	1	Sun's correct declination 3 8 N.
6	6					
7	6					Latitude observed 39 4 N.
8	6					
9	6					
10	6					
11	5					
12	5					Variation ½ point westerly.

Course.	Dist.	Diff. Lat.	Dep	Lat. by D. R.	Lat. by Obs.	Diff. Long.	Long. in.	Bearing and Dist.
S. 42° 29' E.	138	S. 102	E. 93	N. 39° 04'	N. 39° 04'	E. 2° 2'	W. 58° 12'	Funchal S. 79° 4' E. distance 2037 miles

The lee-way and variation being allowed on the courses, they will stand as in the adjoined traverse table. Then with the difference of latitude and departure the course is found to be S. 42° 29' E. and the distance 138 miles.

Yesterday's latitude	40° 46' N.	
Difference of latitude 102' =	1 42 S.	
Latitude in	39 04 N.	
Sum of latitudes	79 50	
Middle latitude	39 55	

With the middle lat. 39° 55' or 40° as a course, and the dep. 93.3, taken as difference of latitude, the diff. of long. is found to be 122 miles = 2° 2' E.

Yesterday's longitude	60 14 W.
Longitude in	58 12 W.

The course made good each day is marked in the journal to degrees and minutes, as it was calculated by logarithms; but for practical purposes, it is sufficiently exact to find it to the nearest degree by means of Table II.

To find the bearing and distance of Funchal.

By Case I. Middle Latitude Sailing.

Latitude in	39° 04' N.	Longitude in	58° 12' W.
Funchal's latitude	32 38 N.	Funchal's longitude	17 05 W
Difference of lat.	6 26 = 386 miles	Difference of long.	41 7
			60
Sum of latitudes	71 42		
Middle latitude	35 51	In miles	2467

With the middle latitude 35° 51' or 36° as a course, and the difference of longitude 2467 as a distance, I calculate the departure; with that and the difference of latitude I find the distance and course, by Case I. of Middle Latitude Sailing.

Remarks on board, Wednes. Mar. 29, 1820.		
These 24 hours moderate, pleasant weather.		
Merid. alt. ☉'s lower limb	55°	32'
Add for semi-diameter, dip, &c.	0	12
☉'s correct altitude	55	44
Subtract from	90	00
☉'s zenith distance	34	16 N.
☉'s correct declination	3	32 N.
Latitude observed	37	48 N.
Variation 1 point westerly.		

by R.	Lat. by Obs.	Diff. Long.	Long. in.	Bearing & Dist.
38'	N. 37° 48'	0	W. 56°12'	Funchal, S. 81°15'E. distance 2038 miles

TRAVERSE TABLE.					
Course.	Dist.	N.	S.	E.	W.
South.	86		86.0	Diff. Lat.	

The leeway and variation being allowed on both courses, they become south; the whole distance sailed or 86 miles, is therefore the difference of latitude by account, the departure being nothing; consequently the ship is in the same longitude as yesterday.

Yesterday's latitude		39° 04' N.
Difference of latitude	86=1	26 S.
Latitude in by D. R.		37 38 N.

The latitude by observation was 37° 48' N. differing 10 miles from the account; but this will not render it necessary to correct the longitude.

To find the bearing and distance of Funchal.

Latitude in	37° 48 N.	Mer. parts	2453	Longitude in	58° 12'W.
Funchal's lat.	32 38 N.	Mer. parts	2073	Funchal's long.	17 5
Diff. of lat.	5 10	Mer. diff. lat.	380	Diff. of long.	41 7
	60				60
In miles	310			In miles	2467

Hence the bearing is found to be S. 81° 15' E. and the distance 2038 miles, by Case I. of Mercator's sailing; and the same may be found by middle latitude, which is the most exact method when the two latitudes differ but little; and it is the way in which the calculation will be made in the rest of the journal.

y, Mar. 31, 1820.

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ly, per azimuth.

Bearing & Dist.

Funchal S. 80° 9'
. dist. 1855 miles.

The variation and lee-way being allowed on both courses, it appears that the ship has made a due east course, the distance sailed 151 miles is the departure, and the difference of longitude is found by case II. of Parallel Sailing. The latitude in is the same as yesterday's lat. 37° 55' N. Taking this as a course and the departure 151, as difference of latitude, the distance which corresponds is the difference of longitude, 191 miles = 3° 11' E.

Yesterday's longitude	57 34 W.
Longitude in	54 23 W.

To find the bearing and distance of Funchal.

Latitude in	37° 55' N.	Longitude in	54° 23' W.
Funchal's lat.	32 38 N.	Funchal's long.	17 05 W.
Diff. of latitude	5 17 = 317 miles.	Diff. of long.	37 18
			60
Sum of latitudes	70 33		
Middle latitude	35 16	In miles	2238

Hence by case I. of Middle Latitude Sailing, the departure is found to be 1827 miles, the bearing of Funchal S. 80° 9' E. and the distance 1855 miles.

The courses being corrected for lee-way and variation, the traverse table will be as here given.

Hence the course is S. 85° 24′ E. distance 202 miles.

Yesterday's latitude	37°	55′ N.
Diff. of latitude		16 S.
Lat. in by account	37	39 N.
Yesterday's long.	54	23 W.
ep. 201.3, the diff. of long. is 255=	4	15 E.
Longitude in by account	50	8 W.

The latitude by observation differs 9 miles from the latitude by dead reckoning, but the longitude requires no correction on this account.

The leeway and variation being allowed on the courses, the traverse table will be as here given; hence the course was S. 79° 56′ E. and the distance 202 miles.

Yesterday's latitude	37°	30′ N.
Difference of latitude		35
Latitude in	36	55 N.
Sum of latitudes	74	25
Middle latitude	37	12

With the middle lat. 37° 12′ and the dep. 198.7, the difference of longitude is found to be 249 miles = 4° 9′ E.

Yesterday's longitude	50	8 W.
Longitude in	45	59 W.

To find the bearing and distance of Funchal.

Latitude in	36°	55′ N.	Longitude in	45°	59′ W.
Funchal's latitude	32	38 N.	Funchal's longitude	17	05 W.
Diff. of latitude	4	17 = 257 m.	Diff. of longitude	28	54
				60	
Sum of latitudes	69	33			
Middle latitude	34	46	In miles	1734	

Hence by Case I. of Middle Latitude Sailing, the bearing of Funchal is found to be S. 79° 16′ E. and its distance 1447 miles.

TRAVERSE TABLE.

The courses being corrected for lee way and variation, will stand as in the adjoined traverse table.

Then with the difference of latitude 82.4 and the departure 63.8, I find the course S 37° 45' E.

Yesterday's latitude	36° 17' N.
Difference of latitude	1 22 S.
Lat. by account	34 55 N.

Yesterday's latitude	36° 17' N.
Latitude in by obs.	34 35 N.
Sum of latitudes,	70 52
Middle latitude	35 26

With the dep. 63.8 miles, and the mid. lat. 35° 26', I find the diff. of long. to be 78 miles= 1° 18' E.

Yesterday's long.	41 34 W.
Longitude in	40 16 W.

To find the bearing and distance of Funchal.

Latitude in	34° 35' N.
Funchal's latitude	32 38 N.
Diff. of latitude	1 57=117 miles.
Middle latitude	33 36

Longitude in	40° 16' W.
Funchal's longitude	17 05 W.
Diff. of longitude	23 11
	60
In miles	1391

Hence by Case I. Middle Latitude Sailing, the bearing of Funchal is found to be S. 84° 14' E. and its distance 1164 miles.

H	K.	F.	Courses.	Winds.	L W.	Remarks on board, Wednesday, Ap. 5, 1820.
1	3		S. E.	E.N.E.	1	First part of these 24 hours small bree-
2	3					zes, and calm; latter part fresh gales.
3	2					At 4 P. M. got out the boat and tried
4	2					the current; found it running E. 1 mile
5						per hour, and suppose the ship has been
6			Calm.			in this current these 24 hours.
7						
8						
9						
10						Mer. alt. sun's lower limb 61° 39′
11						Correction for semi-diam. &c. 0 12
12						
1	3	4	E. S. E.	N.N.E.		Sun's correct altitude 61 51
2	3	4				Subtract from 90 00
3	4	6				
4	4	6				Sun's zenith distance 28 9 N.
5	5	5				Sun's declination 6 12 N.
6	5	5				
7	6	5				Obs. latitude 34 21 N.
8	6	5				
9	7					
10	7					
11	8					
12	8					Variation 1¼ point westerly.

Course.	Dist.	Diff. Lat.	Dep	Lat. by D. R.	Lat. by Obs.	Diff. Long.	Long. in.	Bearing and Dist.
S.83°36′E	101	S. 11	E. 100	N. 34° 24′	N. 34° 21′	E. 2° 1′	W. 38°15′	Funchal S. 84°27′ E distance 1064 miles

In addition to the courses sailed, I also allow 24 miles for the set of the current in the direction of east per compass, or E. N. E. ¾ E. true course.

With the difference of latitude 11.2 and the departure 99.9, the course is found to be S. 83° 36′ E. and the distance nearly 101 miles.

Yesterday's latitude	34° 35′ N.	
Difference of latitude	0 11 S.	
Latitude in by account	34 24 N.	

With the middle lat. 34° 28′, and the dep. 99.9, I find the diff. of long. to be 121 miles= 2° 1′ E.

Yesterday's longitude	40 16 W.
Longitude in	38 15 W.

To find the bearing and distance of Funchal.

Latitude in	34° 21′ N.	Longitude in	38° 15′ W.
Funchal's latitude	32 38 N.	Funchal's longitude	17 5 W.
Difference of lat.	1 43=103 miles	Difference of long.	21 10
Sum of latitudes	66 59		60
Middle latitude	33 30 nearly.	In miles	1270

Hence by Case I. of Middle Latitude Sailing, the bearing of Funchal is found to be S. 84° 27′ E. and its distance 1064 miles.

The course corrected for variation is E. ¾ S. distance 216 miles; hence the difference of latitude is 31.7, and the departure 213.7 miles.

Yesterday's latitude	34°	21′ N.
Difference of latitude		32 S.
Latitude in	33	49 N.
Sum of latitudes by obs.	68	9
Middle latitude	34	4

With the middle latitude 34° 4′ and the departure 213.7 miles, I find the difference of longitude to be 258 miles= 4° 18′ E.

	4°	18′ E.
Yesterday's longitude	38	15 W.
Longitude in	33	57 W.

To find the bearing and distance of Funchal.

Latitude in	33°	48′ N.	Longitude in	33°	57′ W.
Funchal's lat.	32	38 N.	Funchal's long.	17	05 W.
Diff. of latitude	1	10=70 miles.	Diff. of long.	16	52
Sum of latitudes	66	26		60	
Middle latitude	33	13			
			In miles	1012	

Hence the bearing of Funchal is found to be S. 85° 16′ E. and its distance 850 miles.

By the adjoined traverse table, the difference of latitude is 35.2, and the departure 206.8; hence the course was S. 80° 20′ E. and the distance 209.8, or 210 miles.

Yesterday's latitude	33°	48′ N.
Difference of latitude		35′ S.
Latitude in by account	33	13′ N.
Sum of latitudes	67	01
Middle latitude	33	30

With the middle latitude 33° 30′ and the departure 206.8, I find the difference of longitude 248 miles, or

	4°	8′ E.
Yesterday's longitude	33	57 W.
Longitude in	29	49 W.

To find the bearing and distance of Funchal.

Latitude in	33°	13′ N.
Funchal's latitude	32	38 N.
Diff. of latitude		35
Sum of latitudes	65	51
Middle latitude	32	55

Longitude in	29°	49′ W.
Funchal's longitude	17	5 W.
Diff. of longitude	12	44
	60	
In miles	764	

Hence the bearing of Funchal is found to be S. 86° 55′ E. and its distance 642 miles.

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The leeway and variation being allowed on the courses, they will stand as in the adjoined traverse table; then with the difference of latitude 18.7 and the departure 170.7, the course is found to be S. 83° 45' E. and the distance 172 miles.

Yesterday's latitude	33°	13' N.
Difference of latitude		19 S.
Latitude in	32	54 N.
Sum of latitudes	66	07
Middle latitude	33	03

With the middle lat. 33° 03' and the dep. 170.7, I find the diff. of long. in nearly 204 miles= 3° 24' E.

Yesterday's longitude	29	49 W.
Longitude in	26	25 W.

To find the bearing and distance of Funchal.

Latitude in	32°	54' N.	Longitude in	26°	25' W.
Funchal's latitude	32	38 N.	Funchal's longitude	17	05 W.
Diff. of latitude		16	Diff. of longitude	9	20
Sum of latitudes	65	32		60	
Middle latitude	32	46			
			In miles	560	

Hence the bearing of Funchal is found to be S. 88° 3 E. and its distance 471 miles.

The variation being allowed on the courses, they will stand as in the adjoined table; then with the difference of latitude 2.9, and the departure 209.5, the course is found to be N. 89° 12′ E. and the distance 210 miles nearly.

Yesterday's latitude	32°	54′ N.
Difference of latitude		3 N.
Latitude by account	32	57 N.

With the middle lat. 32° 55′, and the dep. 209.5, the diff. of long. is found 250 miles= 4° 10′ E.

Yesterday's longitude	26	25 W.
Longitude in	22	15 W.

To find the bearing and distance of Funchal.

Latitude in	32°	56′ N.
Funchal's latitude	32	38 N.
Difference of latitude		18
Sum of latitudes	65	34
Middle latitude	32	47

Longitude in	22°	15′ W.
Funchal's longitude	17	05 W.
Difference of longitude	5	10
	60	
In miles	310	

Hence the bearing of Funchal is found to be S. 86° 3′ E. and its distance 261 miles.

TRAVERSE TABLE.

In the traverse table are placed the bearing and distance of the land at 10 A. M. (after allowing the variation.) Hence the whole difference of latitude is 27 miles, the departure 242.7, the course S. 83° 39′ E. and the distance 244 miles.

Yesterday's latitude	32°	56′	N.
Difference of latitude		27	S.
Latitude by account	32	29	N.
Sum of latitudes	65	25	
Middle latitude	32	42	

With the middle lat. 32° 42′, and the dep. 242.7, the diff. of long. is found to be 288 miles=

	4°	48′	E.
Yesterday's long.	22	15	W.
	17	27	W.

Therefore the latitude of the southern point of Madeira by my account is 32° 29′ N. and its longitude 17° 27′ W. these values differing but little from the values given in the table of latitudes and longitudes; I therefore conclude, that my journal was nearly exact; and that latitude and longitude of that part of Madeira were well laid down.

H	K	F	Courses.	Winds.	L. W	REMARKS on board, Tuesday, April 11, 1820.
1						Pleasant gales and fair weather.
2						
3						
4						At 4 P. M. came to, off Funchal.
5						
6						
7						
8						
9						At 8 P. M. went on shore.
10						
11						
12						

Courses.	Dist.	Diff. Lat.	Dep.	Lat. by D. R.	Lat. by Obs.	Diff. Long.	Long. in	Bear. and Dist.

AN ABSTRACT OF THE FOREGOING JOURNAL.

Days.	Months.	1820.	Courses.	Dist.	Lat. by D.R.	Lat.by Ob.	Long. in	Bearings and Distances of Funchal at noon.
Saturday,	March	25	N. 86° 58′ E.	94	42° 10′ N.		67° 57′ W.	S. 76° 41′ E. distant 2485 miles.
Sunday,	March	26	S. 80 15 E.	162	41 43	41° 43′ N.	64 22	S. 76 24 E. distant 2319 miles.
Monday,	March	27	S. 75 56 E.	192	40 56	40 46	60 14	S. 76 45 E. distant 2129 miles.
Tuesday,	March	28	S. 42 29 E.	138	39 04	39 04	58 12	S. 79 04 E. distant 2037 miles.
Wednesday,	March	29	South.	86	37 38	37 48	58 12	S. 81 15 E. distant 2038 miles.
Thursday,	March	30	N. 76 17 E.	31	37 55		57 34	S. 80 55 E. distant 2008 miles.
Friday,	March	31	East.	151	37 55		54 23	S. 80 9 E. distant 1855 miles.
Saturday,	April	1	S. 85 24 E.	202	37 39	37 30	50 8	S. 79 48 E. distant 1649 miles.
Sunday,	April	2	S. 79 56 E.	202	36 55		45 59	S. 79 46 E. distant 1447 miles.
Monday,	April	3	S. 79 22 E.	217	36 15	36 17	41 34	S. 79 45 E. distant 1231 miles.
Tuesday,	April	4	S. 37 45 E.	104	34 55	34 35	40 16	S. 84 14 E. distant 1164 miles.
Wednesday,	April	5	S. 83 36 E.	101	34 24	34 21	38 15	S. 84 27 E. distant 1064 miles.
Thursday,	April	6	E. ¼ S.	216	33 49	33 48	33 57	S. 85 16 E. distant 850 miles.
Friday,	April	7	S. 80 20 E.	210	33 18		29 49	S. 86 53 E. distant 642 miles.
Saturday,	April	8	S. 83 45 E.	172	32 54		26 25	S. 88 3 E. distant 471 miles.
Sunday,	April	9	N. 89 12 E.	210	32 57	32. 56	22 15	S. 86 3 E. distant 261 miles.
Monday,	April	10	S. 83 39 E.	244	32 29		17 27	made the land, bearing E. by S. ¼ S. dist. 15 leag.
Tuesday,	April	11	Came to anchor at 4 P. M. in Funchal road.					

or are at a small distance from each other, the transverse position of the former being principally understood. *Athwart the fore Foot;* when any object crosses the line of a ship's course, but a-head of her, it is said to be athwart the Fore Foot. *Athwart ships;* reaching, or in a direction, across the ship from one side to the other.

Atrip. When applied to the anchor, it means that the anchor is drawn out of the ground, and hangs in a perpendicular direction, by the cable or buoy-rope.— The top-sails are said to be atrip, when they are hoisted up to the mast head, or to their utmost extent.

Avast. A term used for stop, or stay; as, *avast heaving*, do not heave any more.

Aweigh. The same as atrip when applied to the anchor.

Awning. A shelter or screen of canvass spread over the decks of a ship, to keep off the heat of the sun. *Spread the awning;* extend it so as to cover the deck. *Furl the awning;* that is, roll it up.

To back the Anchor. To carry out a small anchor ahead of the large one, in order to support it in bad ground, and to prevent it from loosening or coming home.

To back astern. In rowing, is to impel the boat with her stern foremast by means of the oars.

To back the sails. To arrange them in a situation that will occasion the ship to move astern.

To bagpipe the mizen. To lay it aback, by bringing the sheet to the mizen shrouds.

To Balance. To contract a sail into a narrower compass, by folding up a part at one corner. Balancing is peculiar only to the mizen of a ship, and the mainsail of those vessels wherein it is extended by a boom.

Bale. Bale the boat; that is, to throw the water out of her.

Ballast, is either pigs of iron, stones, or gravel, which last is called shingle ballast: and its use is to bring the ship down to her bearings in the water, which her provisions and stores will not do. *Trim the ballast;* that is, spread it about and lay it even. *The Ballast shoots;* that is, it shifts, or runs over from one side of the hole to the other.

Bare Poles. When a ship has no sail set, she is under bare poles.

Barge. A carval built boat, that rows with ten or twelve oars.

Batten. A thin piece of wood. Batten down the hatches, is to lay battens upon the tarpaulins, which are over the hatches in bad weather, and nail them down that they may not be washed off.

Beacon. A post or stake erected over a shoal or sand bank, as a warning to seamen to keep at a distance. Also, a signal placed at the top of hills, &c.

Beams. Strong pieces of timber stretching across a ship's side to side, to support the decks, and retain the sides at their proper distance.

Bear a-hand. Make haste, despatch.

Bearing signifies the point of the compass which any two or more places bear from each other, or how any place bears from the ship by the compass; or it may be said to bear on the beam, abaft the beam, on the bow, the head or stern, &c.

Bearings of a ship, is that line which is formed by the water upon her sides when she is at anchor, with her proportion of ballast, and stores on board. To bear to, is to sail into an harbour, &c. Bear round up; that is, put her right before the wind. Bring your guns to bear, is to point them to the object.

To bear in with the land, is when a ship sails towards the shore.

To Bear off. To thrust or keep off from the ship's side, &c. any weight when hoisting.

Bearing up or *Bearing away.* The act of changing the course of a ship, in order to make her run before the wind, after she had sailed sometime with a side wind, or close hauled; it is generally performed to arrive at some port under the lee, or to avoid some imminent danger occasioned by a violent storm, leak, or enemy in sight.

Beating to Windward. The making a progress against the direction of the wind, by steering alternately close hauled on the starboard and larboard tacks.

To becalm. To intercept the current of the wind, in its passage to a ship, by any contiguous object, as a shore above her sails, a high sea behind, &c. and thus one sail is said to becalm another.

Before the Beam, denotes an arch of the horizon comprehended between the line of the beam (which is at right angles to the keel) and that point of the compass on which the ship stems. See Bearing.

Belay. To make fast any running rope, as Belay the main brace, or make it fast.

Bend. To apply to and fasten; as, bend the sails, apply them to the yards and fasten them: unbend the sails, that is, cast them off, and take them from the yards; her sails are unbent, she has none fixed: bend the cable, make it fast to the anchor.

Beneaped. See Neaped.

Between Decks. The space contained between any two decks of a ship.

Bight of a rope. The double part of a rope when it is folded. Bight, a narrow inlet of the sea.

Bilge. To break. The ship is bilged; that is, her planks are broken in by violence.

Bilge-Water, is that which, by reason of the flatness of a ship's bottom, lies on her floor, and cannot go to the well of the pump.

Binnacle. A kind of box to contain the compasses in upon deck.

Birth. A place; as, *the ship's birth,* the place where she is moored; *an officer's birth,* his place in the ship to eat or sleep in; *birth the ship's company,* that is, allot them their places to mess in; *birth the Hammocks,* point out where each man's hammock is to hang.

Bitts. Very large pieces of timber in the fore part of a ship, round which the cables are fastened when the ship is at anchor. After-Bitts, a smaller kind of bitts upon the quarter-deck, for belaying the running rigging to.

To Bitt the Cable, is to confine the cable to the bitts, by one turn under the cross piece, and another turn round the bitt-head. In this position it may be either kept fixed, or it may be veered away.

Bitter. The turn of the cable round the bitts. *Bitter-end*; that part of the cable which stays within board, round about the bitts, when the ship is at anchor.

Block. A piece of wood with running sheaves or wheels in it, through which the running rigging is passed to add to the purchase.

Board. To board a ship is to enter it in a hostile manner.

Board. To make *a board* is making a stretch upon any tack when a ship is working upon a wind. *To board it up,* that is, to turn to windward. *The ship has made a stern board,* that is, when she loses ground in working upon a wind.

Boatswain. The officer who has charge of all the cordage, rigging, anchors, &c.

Bold shore. A steep coast, permitting the close approach of shipping.

Bolt-rope. The rope which goes round a sail, and to which the canvass is sewed. The side ropes are called *leach ropes,* that at the top the *head rope,* and that at the bottom the *foot rope.*

Bonnet of a sail, is an additional piece of canvass put to the sail in moderate weather to hold more wind. *Lase on the bonnet,* that is, fasten it to the sail. *Shake off the bonnet,* take it off.

Boot topping. Cleaning the upper part of a ship's bottom, or that part which lies immediately under the surface of the water, and daubing it over with tallow, or with a mixture of tallow, sulphur, rosin, &c.

Both sheets aft. The situation of a ship sailing right before the wind.

Bow grace. A frame of old rope or junk, laid out at the bows, stems, and side of ships, to prevent them from being injured by flakes of ice.

Bow lines. Lines made fast to the sides of the sails to haul them forward when upon a wind, which being hauled taut, enables the ship to come nearer to the wind.

To bowse. To pull upon any body with a tackle in order to remove it.

Bowsprit. A large mast or piece of timber which stands out from the bows of a ship.

Boxhauling. A particular method of veering a ship, when the swell of the sea renders tacking impracticable.

Boxing. An operation somewhat similar to Boxhauling. It is performed by laying the head sails aback, to receive the greatest force of the wind in a line perpendicular to their surfaces, in order to turn the ship's head into the line of her course, after she had inclined to windward of it.

Braces. The ropes by which the yards are turned about to form the sails to the wind.

To brace the yards. To move the yards, by means of the braces, to any direction required. *To brace about*—to brace the yards round for the contrary tack. *To brace sharp*—to brace the yards to a position in which they will make the smallest possible angle with the keel, for the ship to have head-way. *To Brace to*—

Dead-wind. The wind right against the ship, or blowing from the very point to which she wants to go.
Dismasted. The state of a ship that has lost her masts.
Dog-vane. A small vane with feathers and cork, and placed on the ship's quarter, for the men at cun and helm to see the course of wind by.
Dog-watch. The watches from four to six, and from six to eight in the evening.
Doubling. The act of sailing round or passing beyond a cape or point of land. Doubling upon—The act of inclosing any part of a hostile fleet between two fires, or of cannonading it on both sides.
Douce. To strike or haul down; as, douce the top-gallant-sails, that is, lower them.
Down haul. The rope by which any sail is hauled down; as the jib down-haul.
To dowse. To lower suddenly or slacken.
To drag the anchor. To trail it along the bottom after it is loosened from the ground.
To draw. When a sail is inflated by the wind, so as to advance the vessel in her course, the sail is said to *draw;* and so to *keep all drawing* is to inflate all the sails.
Drift. The angle which the line of a ship's motion makes with the nearest meridian, when she drives with her side to the wind and waves, and not governed by the power of the helm. It also implies the distance which the ship drives on that line.
Driver. A large sail set upon the mizen yards in light winds. Drive.—The ship drives, that is, her anchor comes through the ground.
Drop. Used sometimes to denote the depth of a sail; as the fore-top-sail drops twelve yards.
To drop anchor. Used synonimously with *to anchor.* To drop astern. The retrogade motion of a ship.
Dunnage. A quantity of loose wood, &c. laid at the bottom of a ship to keep the goods from being damaged.
Earings. Small ropes used to fasten the upper corners of sails to the yards.
To ease, to ease away, or to ease off. To slacken gradually; thus they say, *ease* the bowline, *ease* the sheet.
Ease the ship. The command given by the pilot, to the steersman, to put the helm hard a-lee, when the ship is expected to plunge her fore part deep in the water when close hauled.
To edge away. To decline gradually from the shore or from the line of the course which the ship formerly held in order to go more large.
To edge in with. To advance gradually towards the shore, or any other object.
Elbow in the Hawse. Is when a ship, being moored, has gone round upon the shifting of the tides twice the wrong way, so as to lay the cables one over the other: having gone once wrong, she makes a cross in the hawse, and going three times wrong, she makes a round turn,
End for end. A term used when a rope runs all out of a block, and is unreeved; or in coming to an anchor, if the stoppers are not well put on and the cable runs all out, it is said to have gone out end for end.
End on. When a ship advances to a shore, rock, &c. without an apparent possibility of preventing her, she is said to go *end on* for the shore, &c.
Engagement. Action or fight.
Ensign. The flag worn at the stern of a ship.
Entering port. A large port in the side of three deckers leading into the middle deck, to save the trouble of going up the ship's side to get on board.
Even keel. When the keel is parallel with the horizon, a ship is said to be upon an *even keel.*
Fair. A general term for the disposition of the wind when favorable to a ship's course.
Fair-way. The channel of a narrow bay, river, or haven, in which ships usually advance in their passage up and down.
Fack, or Fake. One circle of any rope or cable quoiled.
Fag-end. The end of any rope which is become untwisted by frequent use; to prevent which the ends of ropes are wound round with pieces of twine, which operation is called *whipping.*
To fall a-board of. To strike or encounter another ship when one or both are in motion. To fall astern—The motion of a ship with her stern foremost. *To fall*

calm. To become in a state of rest by a total cessation of the wind. *To fall down.* To sail or be towed down a river nearer towards its mouth.

Falling off denotes the motion of the ship's head from the direction of the wind. It is used in opposition to *coming to.*

Fall not off, or nothing off. The command of the steersman to keep the ship near the wind.

Fathom. A measure of six feet.

To fetch away. To be shaken or agitated from one side to another so as to loosen any thing which before was fixed.

Fid. A square bar of wood or iron, with shoulders at one end; used to support the weight of the topmast, when erected at the head of a lower-mast.

Fid for splicing. A large piece of wood of a conical figure ; used to extend the strands and layers of cables in splicing.

To fill. To brace the sails so as to receive the wind in them; and advance the ship in her course, after they had been either shivering or braced a-back.

Fish. A large piece of wood. *Fish the mast ;* apply a large piece of wood to it to strengthen it.

Fish-hook. A large hook by which the anchor is received and brought to the cat-head; and the tackle which is used for this purpose is called the fish-tackle.

To fish the anchor. To draw up the flukes of the anchor towards the top of the bow, in order to stow it, after having been catted.

Flag. A general name for colours worn and used by ships of war.

Flat aft. The situation of the sails when their surfaces are pressed aft against the mast by the force of the wind.

To Flat in. To draw in the aftermost lower corner or clue, of a sail towards the middle of the ship, to give the sail a greater power to turn the vessel. *To flat in forward.* To draw in the fore sheet, jib-sheet, and fore-staysail sheet, towards the middle of the ship.

Flaw. A sudden breeze or gust of wind.

Floating. The state of being buoyed up by the water from the ground.

Flood-tide. The state of a tide when it flows or rises.

Flowing sheets. The position of the sheets of the principal sails when they are loosened from the wind so as to receive it into their cavities more nearly perpendicular than when close-hauled, but more obliquely than when the ship sails before the wind. A ship going two or three points large has *flowing sheets.*

Fore. That part of a ship's frame and machinery that lies near the stem. *Fore and aft.* Throughout the whole ship's length. Lengthways of the ship.

Fore-reach. To shoot a-head, or go past another vessel.

To force over. To force a ship violently over a shoal by a great quantity of sail.

Forward. Towards the fore part of a ship.

Foul. Is used in opposition both to clear and fair. As opposed to clear we say, foul weather, foul bottom, foul ground, foul anchor, foul hawse. As opposed to fair, we say foul wind.

To founder. To sink at sea by filling with water.

To free. Pumping is said to free the ship when it discharges more water than leaks into her.

To freshen. When a gale increases it is said to freshen. *To freshen the Hawse.* Veering out or heaving in a little cable to let another part of it endure the stress of the hawseholes. It is also applied to the act of renewing the service round the cable at the hawseholes.

Freshen the ballast. Divide or separate it.

Fresh away. When a ship increases her velocity, she is said to get fresh way.

Full. The situation of the sails, when they are kept distended by the wind.

Full and by. The situation of a ship, with regard to the wind, when close hauled and sailing, so as to steer neither too nigh the direction, nor to deviate to leeward.

To furl. To wrap or roll a sail close up to the yard or stay to which it belongs, and winding a cord around it, to keep it fast.

Gage of the ship. Her depth of water, or what water she draws.

To gain the wind. To arrive on the weather side, or to windward of some ship or fleet in sight, when both are sailing as near the wind as possible.

Gammon the bowsprit. Secure it by turns of a strong rope passed round it, and into the cat-water, to prevent it from having too much motion.

Press of Sail. All the sail that a ship can set or carry.

Preventer. An additional rope employed at times to support any other, when the latter suffers an unusual strain, particularly when blowing fresh, or in a gale of wind.

Pudding and Dolphin. A large and lesser pad made of ropes, and put round the mast under the lower yards.

Purchase. Any sort of mechanical power employed in raising or removing heavy bodies.

Quarters. The respective stations of the officers and people in time of action. *Quartering,* distributing the men into different places. *Quarter-bill,* the list of the ship's company, with their stations for action noticed.

Quarter-wind, is when the wind blows in from that part of the horizon situated on the quarter of the ship. See *On the quarter.*

Quoil, is a rope or cable laid up round, one fake over another.

To Raise. To elevate any distant object at sea by approaching it; thus, *to raise the land* is used in opposition to *lay the land.*

To Rake. To cannonade a ship at the stern or head, so that the balls scour the whole length of the decks.

Range of Cable. A sufficient length of cable drawn upon deck before the anchor is cast loose, to admit of its sinking to the bottom without any check.

Ratlines. The small ropes fastened to the shrouds, by which the men go aloft.

Reach. The distance between any two points on the banks of a river, wherein the current flows in an uninterrupted course.

Ready about! A command of the boatswain to the crew, and implies that all the hands are to be attentive and at their stations for tacking.

Rear. The last division of a squadron, or the last squadron of a fleet. It is applied likewise to the last ship of a line, squadron, or division.

Reef. Part of a sail from one row of eyelet-holes to another. It is applied likewise to a chain of rocks lying near the surface of the water.

Reefing. The operation of reducing a sail by taking in one or more of the reefs.

To Reeve. To pass the end of a rope through any hole, as the channel of a block, the cavity of a thimble, *&c.*

Rendering. The giving way or yielding to the efforts of some mechanical power. It is used in opposition to jambing or sticking.

Ribs of a ship. A figurative expression for the timbers.

Ride at anchor, is when a ship is held by her anchors, and is not driven by wind or tide. To *ride athwart,* is to ride with the ship's side to the tide. To *ride hawse fallen,* is when the water breaks into the hawse in a rough sea.

Rigging. A general name given to all the ropes employed to support the masts, to extend or reduce the sails, or to arrange them to the disposition of the wind.

Righting. Restoring a ship to an upright position, either after she has been laid on a careen, or after she has been pressed down on her side by the wind.

To right the helm, is to bring it into midships, after it has been pushed either to starboard or larboard.

Rigging out a boom. The running out a pole at the end of a yard to extend the foot of a sail.

To rig the capstern. To fix the bars in their respective holes.

Road. A place near the land where ships may anchor, but which is not sheltered.

Robands, or *Ropebands.* Short flat pieces of plaited rope, having an eye worked at one end: they are used in pairs to tie the upper edges of the square sails to their respective yards.

Rolling. The motion by which a ship rocks from side to side like a cradle.

Rough-Tree. A name applied to any mast, yard, or boom, placed in merchant ships, as a rail or fence above the vessel's side, from the quarter-deck to the forecastle.

Rounding-in. The pulling upon any rope which passes through one or more blocks in a direction nearly horizontal; as, *round in* the weather-braces.

Rounding. Old ropes fastened on the cable, near the anchor, to keep it from chafing.

Round-turn. The situation of the two cables of a ship when moored, after they have been several times crossed by the swinging of the ship.

Rounding-up. Similar to *rounding-in,* except that it is applied to ropes and blocks which act in a perpendicular direction.

To Row. To move a boat with oars.

Rowsing. Pulling up a cable or rope without the assistance of tackles.

Stays. Large ropes coming from the mast heads down before the masts, to prevent them from springing, when the ship is sending deep.
Steady! The order to the helmsman to keep the ship in the direction she is going at that instant.
Steering. The art of directing the ship's way by the movement of the helm.
Steerage-way. Such degree of progressive motion of a ship as will give effect to the motion of the helm.
Stem. A circular piece of timber, into which the two sides of a ship are united at the fore-end; the lower end is scarfed to the keel, and the bowsprit rests on the upper end.
To stem the tide. When a ship is sailing against the tide at such a rate as enables her to overcome its power, she is said to *stem the tide.*
Steeve. Turning up. The bowsprit steeves too much, that is, it is too upright.
Sternfast. A rope confining a ship by her stern to any other ship or wharf.
Sternmost. The furthest astern, opposed to *headmost.*
Sternway. The motion by which a ship falls back with her stern foremost.
Stiff. The condition of a ship when she will carry a great quantity of sail without hazard of oversetting. It is used in opposition to *crank.*
Stoppers. Large kind of ropes, which, being fastened to the cable in different places abaft the bitts, are an additional security to the ship at anchor.
To stow. To arrange and dispose a ship's cargo.
Strand. One of the twists or divisions of which a rope is composed. It also implies the sea beach.
Stranded. This term, speaking of a cable or rope, signifies that one of its strands is broken: applied to a vessel, it means that she has run aground and is lost.
To stream the buoy. To let it fall from the ship's side into the water, previously to casting anchor.
Stretch out. A term used to men in a boat when they should pull strong.
To strike. To lower or let down any thing. Used emphatically to denote the lowering of colours in token of surrender to a victorious enemy.
To strike sounding. To touch ground when endeavouring to find the depth of water.
Sued, or *Sewed.* When a ship is on shore and the water leaves her, she is said to be sued; if the water leaves her two feet, she sues, or is sued two feet.
Surf. The swell of the sea that breaks upon shore or on any rock.
To surge the capstern. To slacken the rope heaved round upon it.
Sway away. Hoist.
Swell. The fluctuating motion of the sea either during or after a storm.
Sweeping. The act of dragging the bight or loose part of a rope along the surface of the ground, in a harbour or road, in order to drag up something lost.
Swinging. The act of a ship's turning round her anchor at the change of wind or tide.
To tack. To turn a ship about from one tack to another, by bringing her head to the wind.
Taffarel. The uppermost part of a ship's stern.
Taking in. The act of furling the sails. Used in opposition to *setting.*
Taking a-back. See *a-back.*
Tampkins, or *Tomkins.* The bung, or piece of wood, by which the mouth of a cannon is filled to keep out wet.
Tarpaulin. A cloth of canvass covered with tar or some other composition, so as to make it water proof.
Taught. Improperly though very generally used for *tight.*
Taunt. High or tall. Particularly applied to masts of extraordinary length.
Tell-tale. An instrument which traverses upon an index in the front of the poop-deck, to show the position of the tiller.
Tending. The turning or swinging of a ship round her anchor in a tide-way at the beginning of ebb and flood.
Thwart. See *a-thwart.* *Thwart ships.* See *a-thwart ships.*
Thus. An order to the helmsman to keep the ship in her present situation, when sailing with a scant wind.
To tide. To work in or out of a river, harbour, or channel, by favour of the tide, and anchoring whenever it becomes adverse.
Tide it up. To go with the tide against the wind.
Tide-way. That part of the river in which the tide ebbs and flows strongly.
Tier. A row; as a tier of guns, a tier of casks, a tier of ships, &c. *Tier of a cable.* A range of the fakes or windings of a cable which are laid within one another, in a

To rig a topgallant-mast.

Send down the top-rope, reeve it through the sheeve-hole, and make it fast round the bounds of the mast and standing part of the rope, leaving enough end to make fast to the cap, which done, sway-away, when the head is through the cap, make fast the spare end, or standing part of the top-rope to the cap, cut the seizing, clap on the grommet, then the shrouds, back stays and stay, sway up the mast, fid it, and set the rigging up.

To rig a bowsprit.

Lash the collar fore-stay for the bob-stays and bowsprit shrouds, then the collar for the spring-stays, then the block for the topmast stay, fix the man-rope, gammon the bowsprit, and set bob-stays and shrouds up.

To rig a jib-boom.

Put over the traveller, horses, guys, the topgallant stay-block, and lash on the blocks, for the top gallant bowline and jib down-haul block to the traveller.

To rig a lower yard.

Get it athwart the gunwale, lash the jeers, quarter clue-garnets, bunt-lines, leech-lines and slab-line blocks; then put over the yard-arms, the horses, brace pendants, the yard-tackle pendants, then the top-sail sheet and lift-blocks, reeve the jeers, braces, lifts and yard-tackle falls, truss parcels, sway the yard up, and haul all taut.

To rig a fore-topsail yard.

Reeve a top-rope through the bullock-block and send it down, and having put over the horses, make the top-rope fast to the middle of the yard, stopping it to the yard-arm, sway it up above the top, put over the brace-pendants and lift-blocks, reeve the lifts and braces, cut the yard-arm seizing and cross the yard, lash the tye, bunt-line and clue-line blocks, reeve the tye and haliards, sway it up above the cap, and parcel it, reeve the clue-lines, bunt-lines and reef-tackles.

To rig a topgallant-yard.

Seize the clue-line blocks on, put the horses over the yard-arms, sway it upon the cap and rig the yard-arms, by putting on the brace-pendants and lifts, then cross the yard and parcel it.

Te steer a ship when her rudder is lost.

To take a large spar, or part of a topmast, and cut it flat in the form of a stern-post, bore holes at proper distances in that part which is to be the fore-part of the preventer or additional stern-post, then take the thickest plank on board, and make it as near as possible into the form of a rudder, bore holes at proper distances in the fore-part of it, and in the after part of the preventer stern-post to correspond with each other: and reeve rope grammots through those holes in the rudder, and after-part of the stern-post for the rudder to play upon.

Through the preventer stern-post reeve guys, and at the fore-part of them fix tackles, and then put the machine overboard; when it is in a proper position, or in a line with the ship's stern-post, lash the upper part of the preventer-post to the upper part of the ship's stern-post, then hook tackles at or near the main chains and bowse taut on the guys to confine it to the lower part of the preventer stern-post:—having holes bored through the preventer, and proper stern-post, run an iron bolt through both, taking care not to touch the rudder, which will prevent the false stern-post from rising up or falling down.

By the guys on the after part of the rudder, and tackles affixed to them, the ship may be steered, taking care to bowse taut the tackles on the preventer stern-post to keep it close to the proper stern-post.

TABLE IX. *Semi-diurnal and Semi-nocturnal arches.*—This table exhibits half the time that a celestial object continues above the horizon when the latitude and declination are of the same name, or below when they are of a contrary name; the former time being usually called the semi-diurnal arch, the latter the semi-nocturnal arch; whence the time of rising and setting may be computed, by the following rules.

To find the time of the sun's rising and setting, and the length of the day and night.

RULE. Find the sun's declination at the top of the page and the latitude in either side column, under the former, and opposite the latter, will be the time of the sun's setting if the latitude and declination are of the same name, but the time of rising if of different names.—The time of rising subtracted from 12 hours will give the time of setting, or the time of setting subtracted from 12 hours will give the time of rising. The time of rising being doubled will give the length of the night; and the time of setting being doubled will give the length of the day.

EXAMPLE I.

Let it be required to find the time of the sun's rising and setting, with the length of the day and night in latitude 51° north, the 19th of July, 1820?

The sun's declination on the given day was 20° 51′ north, or 21° nearly, under which, and against the latitude 51°, stand 7 h. 53 m. the time of the sun's setting on the given day, in lat. 51° north, which doubled, gives 15 h. 46 m. the length of the day; and by subtracting 7 h. 53 m. from 12 h. the remainder 4 h. 7 m. is the time of the sun's rising, which doubled gives 8 h. 14 m. the length of the night.

But, when the sun has 21° south declination in this latitude, the time of sun setting becomes 4 h. 7 m. the time of rising 7 h. 53 m. the length of the day 8 h. 14 m. and the length of the night 15 h. 46 m. as was the case nearly on the 26th November, 1820.

EXAMPLE II.

Let it be required to find the time of the sun's rising, setting, and the length of the day and night, at Boston, the 12th of July, 1820?

	h.	m.
Under 22°, which is nearly the declination on that day, and against 42° 23′ or 42° N. the latitude of Boston, stands the time of the sun's setting	7	25
Subtracted from 12 h. leaves sun-rising	4	35
Sun-setting doubled is the length of day	14	50
Sun-rising doubled is the length of night	9	10

EXAMPLE III.

Required the time of the sun's rising and setting and length of day in latitude 34° 20′ S. May 15th, 1820?

Under the declination 18° 55′ or 19° N. and against the lat. 34° S.	12	0
Stands the sun's rising	6	54
Time of sun's setting	5	6
		2
The length of the day	10	12
And 6h. 54m. doub. is length of night	13	48

When a great degree of accuracy is required, proportional parts may be taken for the minutes of latitude and declination.

To find the time of rising and setting of stars whose declination does not exceed 23° 28′.

Enter Table IX. and find the star's declination at the top, and the latitude at the side; under the former, and opposite to the latter, will be the semi-diurnal arch, when the latitude and declination are both north or both south; but if one be north and the other south, the difference between the Tabular number and 12 hours will be the semi-diurnal arch. Find the time of the star's coming to the meridian according to the precepts of Table VIII. and subtract therefrom the semi-diurnal arch, the difference will be the time of rising; or by adding together the semi-diurnal arch, and the time of passing the meridian, the time of setting will be obtained.

EXAMPLE IV.

Required when the star Arcturus rises and sets December 1, in latitude 51° N.?

	h.	m.
The time of the star's coming to the meridian, or southing in the morning, is nearly	9	38
Then under star's declination 20° nearly, and against latitude 51° stand	7	47
Time of star's rising in the morning	1	51
Added, gives the time of the star's setting	17	25
	12	
Star sets 25 minutes after 5 in the evening	5	25

EXAMPLE V.

What time will the Dog-Star Sirius rise and set at Philadelphia, Feb. 1?

	h.	m.
Under the declination, which is nearly 16° S. and against the latitude,	12	0
which is nearly 40° N. stand	6	56
Subtracted from 12h. leaves half the time the star is above the horizon	5	4
The star comes to the meridian in the evening nearly at	9	39
Sum, rejecting 12 hours, is the time of setting in the morning	2	43
Difference is the time of rising in the evening	4	35

In like manner may the rising and setting of any planet be found when the declination does not exceed 23° 28′, and the time of the passage over the meridian is known.

Suppose *it was required to find the time of Jupiter's rising and setting, March 8, 1820, civil account, in the latitude of* 52° N?

for parallax and refraction. It will be unnecessary here to point out the method of taking out this correction, as it is fully explained in the first pages of the table. It may not, however, be amiss to observe, that after constructing the logarithms of this table, it was concluded to subtract therefrom the greatest correction of the Table C corresponding, in order to render those corrections additive. Thus the logarithm corresponding to the alt 30° and hor. par. 54′, was found at first to be 2372; and for the hor. par. 54′ 10″ the correction was 2358; so that if these numbers had been published, the correction for seconds of parallax would have been subtractive; but as this would have been inconvenient, it was thought expedient to subtract from each of the numbers thus calculated the greatest corresponding correction of Table C, which in the preceding example is 12; by this means the above numbers were reduced to 2360 and 2346 respectively, and the corrections of Table C were rendered additive. In a similar manner the rest of the logarithms of the table were calculated. It is owing to this circumstance that the corrections in Table C for 0″ of parallax are greater than for any other number. Similar methods were used in calculating the other numbers of this table, and in arranging the Tables A and B.

TABLE XX. *Third correction of the apparent distance.*—The method of finding the correction from this table is explained in pages 154, 160, 162.

TABLE XXI. *To reduce longitude into time, and the contrary.* In the first column of this table are contained degrees and minutes of longitude, in the second the corresponding hours and minutes, or minutes and seconds of time; the other columns are a continuation of the first and second respectively. The use of this table will evidently appear by a few examples.

EXAMPLE I.

Required the time corresponding to 50° 31′?

	h. m. s.
Opposite 50° in col. 1 is	3 20 0
31′	2 4
Sought time	3 22 4

EXAMPLE II.

Required the degrees and minutes corresponding to 6h. 33m. 20s.?

Opposite	6h. 32m. 0s.	in col. 4 is	98° 0′
	1 20	in col. 2 is	20
	6 33 20		98 20

TABLE XXII. *Proportional Logarithms.*—These logarithms are very useful in finding the apparent time at Greenwich corresponding to the true distance of the moon from the sun or a star, as is explained in page 154. They may be also used like common logarithms, in working any proportion where the terms are given in degrees, minutes, and seconds; or in hours, minutes, and seconds, as in the examples page 163. The table is extended only to 3° or 3h. and if any of the terms of a given proportion exceed 3° or 3h. you may take all the terms one grade lower; that is, reckon degrees as minutes, minutes as seconds, &c. and work the proportion as before; observing to write down the answer one grade higher; that is, you must estimate minutes as degrees, seconds as minutes, &c. Instead of taking all the terms one grade lower, you may change two of the terms only, viz. one of the middle terms and one of the extreme terms; thus the 1st. and 3d. or the 1st. and 2d. may be taken one grade less, and the fourth term will be given correctly; but if the fourth term be taken one grade less, you must, after working the proportion, write it one grade higher, as is evident. To illustrate this we shall give the following examples.

EXAMPLE I.

If in 15′ 10″ of time the sun rises 2° 40′ how much will it rise in 3′ 10″ at the same rate?

As	15′ 10″	Prop. Log.	ar. co.	8.9256
Is to	2° 40′	Prop. Log.		.0512
So is	3′ 10″	Prop. Log.		1.7547
To	33′ 24″	Prop. Log.		.7315

EXAMPLE II.

If the sun's declination changes 16′ 19″ in 24 hours, how much will it change in 8h. 2m.?

Here the 1st and 3d terms must be taken one grade less.

As	24′ 0″	P. L.	ar. co.	9.1249
Is to	16′ 19″	P. L.		1.0426
So is	8′ 2″	P. L.		1.3504
To	5′ 28″	P. L.		1.5179

EXAMPLE III.

If in 12h. the moon's longitude varies 7° 1′ what will it vary in 4h. 20m.?

Here all the terms must be taken one grade less.

As	12′ 0″	P. L.	ar. co.	8.8239
Is to	7 1	P. L.		1.4091
So is	4 20	P. L.		1.6185
To	2′ 32″ 2‴	P. L.		1.8515

Which taken one grade higher is 2° 32′ 2″ the answer required.

EXAMPLE IV.

If in 16′ the sun rises 3° 27′ how much will it rise in 3′ 10″?

Here the 2d and 4th terms must be taken one grade less.

As	16′ 0″	ar. co.	P. L.	8.9488
Is to	3 27	P. L.		1.7175
So is	3 10	P. L.		1.7547
To	0′ 41″	P. L.		2.4210

Which taken one grade higher is 41′, the answer required.

TABLE XXIII. *For finding the latitude by two altitudes of the sun.*—The manner of using this table is explained in page 128, et seq.

The third and fourth examples may be worked by a single entry of Table XXXI. as follows.

EXAMPLE III.

	d.	h.	m.
Given time by N. A. May	23	4	0
Long. 45° in time add		3	0
Time at Greenwich	23	7	0

	h.	m.	s.
Sun's R. A. May 23, at noon by N. A.	4	0	25
Corr. Tab. XXXI. for 7h.		1	11
Sun's R. A. at 4h. P. M.	4	1	36

Differing 1s. from the former method.

EXAMPLE IV.

	d.	h.	m.
Given time by N. A. June	23	21	0
Long. 120° in time		8	0
Time at Greenwich	23	13	0

	h.	m.	s.
Sun's R. A. June 23, at noon	6	8	1
Corr. Tab. XXXI. for 12h.		2	5
for 1h.			10
Sun's R. A. 21h. 0m.	6	10	16

If you wish to find accurately the time that any star comes to the meridian, or the time of rising or setting, you must take the sun's right ascension for noon at Greenwich, from the Nautical Almanac; then the star's right ascension from Table VIII. and with these, find the approximate time of rising, setting, or coming to the meridian, by the method already given in the precepts for using Tables VIII. and IX. Then calculate the sun's right ascension for this approximate time, and repeat the operation till the assumed and calculated times agree, and you will have the true time required.

To explain this method, I shall give the following examples.

To find the time when a star comes to the meridian.

EXAMPLE I.

At what time was Aldebaran on the meridian of a place in the longitude of 70° 50′ W. Jan. 2, 1820, sea account?

		h.	m.	s.
Jan. 2, sea account, is Jan. 1, N. A. on which day the sun's R. A. at noon at Greenwich was		18	43	48
Aldebaran's R. A.	4h. 25m. 36s.			
Add	24			
		28	25	36
Difference is the approximate time		9	41	48

Now calculating the sun's R. A. for this time in the long. of 70° 50′ W.

	h.	m.	s.
from Greenwich, I find it was	18	46	27
Aldebaran's R. A. + 24h.	28	25	36
True time of coming to the merid.	9	39	9

EXAMPLE II.

At what time was Pollux on the meridian of a place in the longitude of 70° 46′ W. March 31 1820, sea account?

	h.	m.	s.
March 31, sea account, is March 30, N. A. on which day, at noon, the sun's right ascension was	0	35	41
This, subtracted from R. A. of Pollux	7	34	17
Approximate time of southing	6	58	36
Correction of the sun's R. A. from Tab. XXXI. for this time is		1	4
And for the long. 70° 46′ W. of Greenw.			43
The sum of these two corrections is		1	47

which subtracted from the approximate time of southing 6h. 58m. 36s. leaves the true time 6h. 56m. 49s.

The method (used in the last example) of applying the corrections to the approximate time, instead of applying them to the right ascension of the sun, will be found the most expeditious; but it must be noted, that the corrections to be applied to the approximate time must have a contrary sign to what they would have when applied to the right ascension.

To find the time of rising or setting of a star.

RULE. Enter Table IX. with the declination of the star at the top, and the latitude of the place at the side; the corresponding number will be the time of the star's continuance above the horizon, when the latitude and declination are of the same name; but if they are of different names, the tabular number subtracted from 12h. will be the time of continuance above the horizon. Add this time to the star's right ascension, if you wish to find the time of setting; but subtract the former from the latter if you wish the time of rising. From this sum or difference subtract the sun's right ascension* corrected for the longitude of the place; the remainder will be the approximate time sought.† Enter Table XXXI. with the distance of this approximate time from noon, and the daily variation of the sun's right ascension: the correction corresponding is to be added to the approximate time in the forenoon, but subtracted in the afternoon, and you will have the corrected time of rising or setting.

* Increasing the number from which the subtraction is to be made, by 24 hours, when necessary.

† Rejecting 24 hours when it exceeds 24 hours. If the time of rising or setting be more than 12h. will be after midnight; but if less than 12h. it will be before midnight.

EXAMPLE I. Required the Longitude and Latitude of α Pegasi, July 16, 1818?

Long. by Table XXXVII.	11s. 20° 58′ 44″	Latitude by Table XXXVII.	19° 24′ 44″ N.
Variation 1 year 5 1-2 m. sub.	1′ 13″	Variation 1 year 5 1-2 m. sub.	0
Long. July 16, 1818	11 20 57 31		19 24 44 N.

EXAMPLE II. Required the Longitude and Latitude of α Pegasi, July 1, 1822?

Long. by Table XXXVII.	11s. 20° 58′ 44″	Latitude by Table XXXVII.	19° 24′ 44″ N.
Variation 2 1-2 years, add	2 5	Var. 2 1-2 years, add	0
Long. July 1, 1822	11 21 0 49	Latitude July 1, 1822	19 24 44 N.

The latitudes and longitudes, thus obtained, are the mean values. When great accuracy is required, the corrections for the equation of the equinoxes, Table XL. and aberration, Table XLI. must be applied.

TABLE XXXVIII. *Reduction of latitude and horizontal parallax.*—This table contains the corrections to be subtracted from the latitude of the place of observation, and from the horizontal parallax of the Moon, given in the Nautical Almanac, in calculating eclipses of the Sun or occultations. Thus, if the latitude of the place was 40°, and the Moon's horizontal parallax 57′, the correction of latitude would be nearly—11′ 18″, and that of parallax — 4″.7, so that the reduced latitude would be 39° 48′ 42″, and the reduced parallax 56′ 55″.3. These values are to be used in occultations, but in eclipses of the Sun, this parallax is to be further decreased by 8″.8 for the Sun's parallax. When the latitude is not given exactly in the table, the two nearest numbers must be found, and a proportional part of their difference is to be applied to one of the numbers, as usual. In calculating this table, the ellipticity of the earth was supposed equal to $\frac{1}{300}$, as in the third edition of La Lande's Astronomy, and in Vince's Astronomy. This value differs but little from $\frac{1}{304.6}$ and $\frac{1}{303.05}$, deduced by La Place from two lunar equations in the third volume of his immortal work, *La Mecanique Celeste*. In the second volume of the same work he calculated the ellipticity to be $\frac{1}{336}$ from the lengths of pendulums observed in different latitudes, this calculation corrected for a small mistake in the numerical coefficient of y in the tenth of his equations A″ becomes $\frac{1}{318}$ which does not differ very much from the value assumed in this table.

TABLE XXXIX. *Aberration of the Planets.*—This table contains the aberration of the planets, to be applied to the *true* longitude or latitude, with the *same sign* as in the table. The argument at the side is the elongation of the planet from the Sun; that is, the difference of their geocentric longitudes, or its supplement to 360°. Thus, on July 19, 1820, the longitude of the Sun was 3s. 26° 38′, the Geo. long. of Venus 4s. 13° 23′, their difference 16° 45′ is the elongation or distance from the inferior conjunction, corresponding to which is the aberration + 3″ to be applied to the true longitude given by the tables to obtain the apparent longitude. The aberration of Mercury is given at its greatest, least, and mean distances from the Sun. At the intermediate places, a proportional part of the differences of the nearest tabular numbers must be applied.

TABLES XL. & XLI. *Equation of the Equinoxes and Aberration in Longitude.*—Table XL. contains the equation of the equinoxes in longitude common to all the heavenly bodies. The argument is the longitude of the Moon's ascending node, given in page 3 of the Nautical Almanac, the signs of longitude being found at the top or bottom, and the degrees at the side, the corresponding number with its sign is the equation of the equinoxes in longitude.

Table XLI. contains the aberration of the stars in longitude and latitude, to be calculated by the rules at the bottom of the tables. The signs of the argument being found at the top, and the degrees at the side,* taking proportional parts for minutes. The corrections of longitude found in these tables, are to be applied, with their signs, to the mean longitude found in Table XXXVII. and the correction of latitude, Table XLI. is to be applied to the mean latitude deduced from Table XXXVII. Thus on July 16, 1820, by the examples at the bottom of Tables XL. XLI. the equation of the equinoxes was + 1″.2 and the aberration in longitude + 11″.5, these corrections being applied to the mean longitude of the star deduced from table XXXVII. 11s. 20° 59′ 11″ gives its apparent longitude 11s. 20° 59′ 24″. In a simi-

* The degrees in this and the following tables are to be found in the column marked D on the same horizontal line with the signs. Thus, if the signs are at the top of the table, the degrees must be found on the left column, otherwise in the right.

TABLE I.

Difference of Latitude and Departure for ½ Point.

TABLE II.

Difference of Latitude and Departure for 24 Degrees.

Difference of Latitude and Departure for 37 Degrees.

Dist.	Lat.	Dep.	Dist.	Lat.	Dep.	Dist.	Lat.	Dep.	Dist.	Lat.	Dep.	Dist.	Lat.	Dep.
1	00.8	00.6	61	48.7	36.7	121	96.6	72.8	181	144.6	108.9	241	192.5	145.0
2	01.6	01.2	62	49.5	37.3	22	97.4	73.4	82	145.4	109.5	42	193.3	145.6
3	02.4	01.8	63	50.3	37.9	23	98.2	74.0	83	146.2	110.1	43	194.1	146.2
4	03.2	02.4	64	51.1	38.5	24	99.0	74.6	84	146.9	110.7	44	194.9	146.8
5	04.0	03.0	65	51.9	39.1	25	99.8	75.2	85	147.7	111.3	45	195.7	147.4
6	04.8	03.6	66	52.7	39.7	26	100.6	75.8	86	148.5	111.9	46	196.5	148.0
7	05.6	04.2	67	53.5	40.3	27	101.4	76.4	87	149.3	112.5	47	197.3	148.6
8	06.4	04.8	68	54.3	40.9	28	102.2	77.0	88	150.1	113.1	48	198.1	149.3
9	07.2	05.4	69	55.1	41.5	29	103.0	77.6	89	150.9	113.7	49	198.9	149.9
10	08.0	06.0	70	55.9	42.1	30	103.8	78.2	90	151.7	114.3	50	199.7	150.5
11	08.8	06.6	71	56.7	42.7	131	104.6	78.8	191	152.5	114.9	251	200.5	151.1
12	09.6	07.2	72	57.5	43.3	32	105.4	79.4	92	153.3	115.5	52	201.3	151.7
13	10.4	07.8	73	58.3	43.9	33	106.2	80.0	93	154.1	116.2	53	202.1	152.3
14	11.2	08.4	74	59.1	44.5	34	107.0	80.6	94	154.9	116.8	54	202.9	152.9
15	12.0	09.0	75	59.9	45.1	35	107.8	81.2	95	155.7	117.4	55	203.7	153.5
16	12.8	09.6	76	60.7	45.7	36	108.6	81.8	96	156.5	118.0	56	204.5	154.1
17	13.6	10.2	77	61.5	46.3	37	109.4	82.4	97	157.3	118.6	57	205.2	154.7
18	14.4	10.8	78	62.3	46.9	38	110.2	83.1	98	158.1	119.2	58	206.0	155.3
19	15.2	11.4	79	63.1	47.5	39	111.0	83.7	99	158.9	119.8	59	206.8	155.9
20	16.0	12.0	80	63.9	48.1	40	111.8	84.3	200	159.7	120.4	60	207.6	156.5
21	16.8	12.6	81	64.7	48.7	141	112.6	84.9	201	160.5	121.0	261	208.4	157.1
22	17.6	13.2	82	65.5	49.3	42	113.4	85.5	02	161.3	121.6	62	209.2	157.7
23	18.4	13.8	83	66.3	50.0	43	114.2	86.1	03	162.1	122.2	63	210.0	158.3
24	19.2	14.4	84	67.1	50.6	44	115.0	86.7	04	162.9	122.8	64	210.8	158.9
25	20.0	15.0	85	67.9	51.2	45	115.8	87.3	05	163.7	123.4	65	211.6	159.5
26	20.8	15.6	86	68.7	51.8	46	116.6	87.9	06	164.5	124.0	66	212.4	160.1
27	21.6	16.2	87	69.5	52.4	47	117.4	88.5	07	165.3	124.6	67	213.2	160.7
28	22.4	16.9	88	70.3	53.0	48	118.2	89.1	08	166.1	125.2	68	214.0	161.3
29	23.2	17.5	89	71.1	53.6	49	119.0	89.7	09	166.9	125.8	69	214.8	161.9
30	24.0	18.1	90	71.9	54.2	50	119.8	90.3	10	167.7	126.4	70	215.6	162.5
31	24.8	18.7	91	72.7	54.8	151	120.6	90.9	211	168.5	127.0	271	216.4	163.1
32	25.6	19.3	92	73.5	55.4	52	121.4	91.5	12	169.3	127.6	72	217.2	163.7
33	26.4	19.9	93	74.3	56.0	53	122.2	92.1	13	170.1	128.2	73	218.0	164.3
34	27.2	20.5	94	75.1	56.6	54	123.0	92.7	14	170.9	128.8	74	218.8	164.9
35	28.0	21.1	95	75.9	57.2	55	123.8	93.3	15	171.7	129.4	75	219.6	165.5
36	28.8	21.7	96	76.7	57.8	56	124.6	93.9	16	172.5	130.0	76	220.4	166.1
37	29.5	22.3	97	77.5	58.4	57	125.4	94.5	17	173.3	130.6	77	221.2	166.7
38	30.3	22.9	98	78.3	59.0	58	126.2	95.1	18	174.1	131.2	78	222.0	167.3
39	31.1	23.5	99	79.1	59.6	59	127.0	95.7	19	174.9	131.8	79	222.8	167.9
40	31.9	24.1	100	79.9	60.2	60	127.8	96.3	20	175.7	132.4	80	223.6	168.5
41	32.7	24.7	101	80.7	60.8	161	128.6	96.9	221	176.5	133.0	281	224.4	169.1
42	33.5	25.3	02	81.5	61.4	62	129.4	97.5	22	177.3	133.6	82	225.2	169.7
43	34.3	25.9	03	82.3	62.0	63	130.2	98.1	23	178.1	134.2	83	226.0	170.3
44	35.1	26.5	04	83.1	62.6	64	131.0	98.7	24	178.9	134.8	84	226.8	170.9
45	35.9	27.1	05	83.9	63.2	65	131.8	99.3	25	179.7	135.4	85	227.6	171.5
46	36.7	27.7	06	84.7	63.8	66	132.6	99.9	26	180.5	136.0	86	228.4	172.1
47	37.5	28.3	07	85.5	64.4	67	133.4	100.5	27	131.3	136.6	87	229.2	172.7
48	38.3	28.9	08	86.3	65.0	68	134.2	101.1	28	182.1	137.2	88	230.0	173.3
49	39.1	29.5	09	87.1	65.6	69	135.0	101.7	29	182.9	137.8	89	230.8	173.9
50	39.9	30.1	10	87.8	66.2	70	135.8	102.3	30	183.7	138.4	90	231.6	174.5
51	40.7	30.7	111	88.6	66.8	171	136.6	102.9	231	184.5	139.0	291	232.4	175.1
52	41.5	31.3	12	89.4	67.4	72	137.4	103.5	32	185.3	139.6	92	233.2	175.7
53	42.3	31.9	13	90.2	68.0	73	138.2	104.1	33	186.1	140.2	93	234.0	176.3
54	43.1	32.5	14	91.0	68.6	74	139.0	104.7	34	186.9	140.8	94	234.8	176.9
55	43.9	33.1	15	91.8	69.2	75	139.8	105.3	35	187.7	141.4	95	235.6	177.5
56	44.7	33.7	16	92.6	69.8	76	149.6	105.9	36	188.5	142.0	96	236.4	178.1
57	45.5	34.3	17	93.4	70.4	77	141.4	106.5	37	189.3	142.6	97	237.2	178.7
58	46.3	34.9	18	94.2	71.0	78	142.2	107.1	38	190.1	143.2	98	238.0	179.3
59	47.1	35.5	19	95.0	71.6	79	143.0	107.7	39	190.9	143.8	99	238.8	179.9
60	47.9	36.1	20	95.8	72.2	80	143.8	108.3	40	191.7	144.4	300	239.6	180.5
Dist.	Dep.	Lat.	Dist.	Dep.	Lat.	Dist.	Dep.	Lat.	Dist.	Dep.	Lat.	Dist.	Dep.	Lat.

[For 53 Degrees.

Difference of Latitude and Departure for 43 Degrees.

Dist.	Lat.	Dep.	Dist.	Lat.	Dep.	Dist.	Lat.	Dep.	Dist.	Lat.	Dep.	Dist.	Lat.	Dep.
1	00.7	00.7	61	44.6	41.6	121	88.5	82.5	181	132.4	123.4	241	176.3	164.4
2	01.5	01.4	62	45.3	42.3	22	89.2	83.2	82	133.1	124.1	42	177.0	165.0
3	02.2	02.0	63	46.1	43.0	23	90.0	83.9	83	133.8	124.8	43	177.7	165.7
4	02.9	02.7	64	46.8	43.6	24	90.7	84.6	84	134.6	125.5	44	178.5	166.4
5	03.7	03.4	65	47.5	44.3	25	91.4	85.2	85	135.3	126.2	45	179.2	167.1
6	04.4	04.1	66	48.3	45.0	26	92.2	85.9	86	136.0	126.9	46	179.9	167.8
7	05.1	04.8	67	49.0	45.7	27	92.9	86.6	87	136.8	127.5	47	180.6	168.5
8	05.9	05.5	68	49.7	46.4	28	93.6	87.3	88	137.5	128.2	48	181.4	169.1
9	06.6	06.1	69	50.5	47.1	29	94.3	88.0	89	138.2	128.9	49	182.1	169.8
10	07.3	06.8	70	51.2	47.7	30	95.1	88.7	90	139.0	129.6	50	182.8	170.5
11	08.0	07.5	71	51.9	48.4	131	95.8	89.3	191	139.7	130.3	251	183.6	171.2
12	08.8	08.2	72	52.7	49.1	32	96.5	90.0	92	140.4	130.9	52	184.3	171.9
13	09.5	08.9	73	53.4	49.8	33	97.3	90.7	93	141.2	131.6	53	185.0	172.5
14	10.2	09.5	74	54.1	50.5	34	98.0	91.4	94	141.9	132.3	54	185.8	173.2
15	11.0	10.2	75	54.9	51.1	35	98.7	92.1	95	142.6	133.0	55	186.5	173.9
16	11.7	10.9	76	55.6	51.8	36	99.5	92.8	96	143.3	133.7	56	187.2	174.6
17	12.4	11.6	77	56.3	52.5	37	100.2	93.4	97	144.1	134.4	57	188.0	175.3
18	13.2	12.3	78	57.0	53.2	38	100.9	94.1	98	144.8	135.0	58	188.7	176.0
19	13.9	13.0	79	57.8	53.9	39	101.7	94.8	99	145.5	135.7	59	189.4	176.6
20	14.6	13.6	80	58.5	54.6	40	102.4	95.5	200	146.3	136.4	60	190.2	177.3
21	15.4	14.3	81	59.2	55.2	141	103.1	96.2	201	147.0	137.1	261	190.9	178.0
22	16.1	15.0	82	60.0	55.9	42	103.9	96.8	02	147.7	137.8	62	191.6	178.7
23	16.8	15.7	83	60.7	56.6	43	104.6	97.5	03	148.5	138.4	63	192.3	179.4
24	17.6	16.4	84	61.4	57.3	44	105.3	98.2	04	149.2	139.1	64	193.1	180.0
25	18.3	17.0	85	62.2	58.0	45	106.0	98.9	05	149.9	139.8	65	193.8	180.7
26	19.0	17.7	86	62.9	58.7	46	106.8	99.6	06	150.7	140.5	66	194.5	181.4
27	19.7	18.4	87	63.6	59.3	47	107.5	100.3	07	151.4	141.2	67	195.3	182.1
28	20.5	19.1	88	64.4	60.0	48	108.2	100.9	08	152.1	141.9	68	196.0	182.8
29	21.2	19.8	89	65.1	60.7	49	109.0	101.6	09	152.9	142.5	69	196.7	183.5
30	21.9	20.5	90	65.8	61.4	50	109.7	102.3	10	153.6	143.2	70	197.5	184.1
31	22.7	21.1	91	66.6	62.1	151	110.4	103.0	211	154.3	143.9	271	198.2	184.8
32	23.4	21.8	92	67.3	62.7	52	111.2	103.7	12	155.0	144.6	72	198.9	185.5
33	24.1	22.5	93	68.0	63.4	53	111.9	104.3	13	155.8	145.3	73	199.7	186.2
34	24.9	23.2	94	68.7	64.1	54	112.6	105.0	14	156.5	145.9	74	200.4	186.9
35	25.6	23.9	95	69.5	64.8	55	113.4	105.7	15	157.2	146.6	75	201.1	187.5
36	26.3	24.6	96	70.2	65.5	56	114.1	106.4	16	158.0	147.3	76	201.9	188.2
37	27.1	25.2	97	70.9	66.2	57	114.8	107.1	17	158.7	148.0	77	202.6	188.9
38	27.8	25.9	98	71.7	66.8	58	115.6	107.8	18	159.4	148.7	78	203.3	189.6
39	28.5	26.6	99	72.4	67.5	59	116.3	108.4	19	160.2	149.4	79	204.0	190.3
40	29.3	27.3	100	73.1	68.2	60	117.0	109.1	20	160.9	150.0	80	204.8	191.0
41	30.0	28.0	101	73.9	68.9	161	117.7	109.8	221	161.6	150.7	281	205.5	191.6
42	30.7	28.6	02	74.6	69.6	62	118.5	110.5	22	162.4	151.4	82	206.2	192.3
43	31.4	29.3	03	75.3	70.2	63	119.2	111.2	23	163.1	152.1	83	207.0	193.0
44	32.2	30.0	04	76.1	70.9	64	119.9	111.8	24	163.8	152.8	84	207.7	193.7
45	32.9	30.7	05	76.8	71.6	65	120.7	112.5	25	164.6	153.4	85	208.4	194.4
46	33.6	31.4	06	77.5	72.3	66	121.4	113.2	26	165.3	154.1	86	209.2	195.1
47	34.4	32.1	07	78.3	73.0	67	122.1	113.9	27	166.0	154.8	87	209.9	195.7
48	35.1	32.7	08	79.0	73.7	68	122.9	114.6	28	166.7	155.5	88	210.6	196.4
49	35.8	33.4	09	79.7	74.3	69	123.6	115.3	29	167.5	156.2	89	211.4	197.1
50	36.6	34.1	10	80.4	75.0	70	124.3	115.9	30	168.2	156.9	90	212.1	197.8
51	37.3	34.8	111	81.2	75.7	171	125.1	116.6	231	168.9	157.5	291	212.8	198.5
52	38.0	35.5	12	81.9	76.4	72	125.8	117.3	32	169.7	158.2	92	213.6	199.1
53	38.8	36.1	13	82.6	77.1	73	126.5	118.0	33	170.4	158.9	93	214.3	199.8
54	39.5	36.8	14	83.4	77.7	74	127.3	118.7	34	171.1	159.6	94	215.0	200.5
55	40.2	37.5	15	84.1	78.4	75	128.0	119.3	35	171.9	160.3	95	215.7	201.2
56	41.0	38.2	16	84.8	79.1	76	128.7	120.0	36	172.6	161.0	96	216.5	201.9
57	41.7	38.9	17	85.6	79.8	77	129.4	120.7	37	173.3	161.6	97	217.2	202.6
58	42.4	39.6	18	86.3	80.5	78	130.2	121.4	38	174.1	162.3	98	217.9	203.2
59	43.1	40.2	19	87.0	81.2	79	130.9	122.1	39	174.8	163.0	99	218.7	203.9
60	43.9	40.9	20	87.8	81.8	80	131.6	122.8	40	175.5	163.7	300	219.4	204.6
Dist.	Dep.	Lat.	Dist.	Dep.	Lat.	Dist.	Dep.	Lat.	Dist.	Dep.	Lat.	Dist.	Dep.	Lat.

[For 47 Degrees.

TABLE III.

MERIDIONAL PARTS.

M.	28d.	29d.	30d.	31d.	32d.	33d.	34d.	35d.	36d.	37d.	38d.	39d.	40d.	41d.	M.
0	1751	1819	1888	1958	2028	2100	2171	2244	2318	2393	2468	2545	2623	2702	0
1	52	21	90	59	30	01	73	46	19	94	70	46	24	03	1
2	53	22	91	60	31	02	74	47	20	95	71	48	25	04	2
3	55	23	92	62	32	03	75	48	22	96	72	49	27	06	3
4	56	24	93	63	33	04	76	49	23	98	73	50	28	07	4
5	1757	1825	1894	1964	2034	2105	2178	2250	2324	2399	2475	2551	2629	2708	5
6	58	26	95	65	35	07	79	52	25	2400	76	53	31	10	6
7	59	27	96	66	37	08	80	53	27	01	77	54	32	11	7
8	60	29	98	67	38	09	81	54	28	03	78	55	33	12	8
9	61	30	99	69	39	10	82	55	29	04	80	57	34	14	9
10	1762	1831	1900	1970	2040	2111	2184	2257	2330	2405	2481	2558	2636	2715	10
11	64	32	01	71	41	13	85	58	32	06	82	59	37	16	11
12	65	33	02	72	43	14	86	59	33	08	84	60	38	18	12
13	66	34	03	73	44	15	87	60	34	09	85	62	40	19	13
14	67	35	05	74	45	16	88	61	35	10	86	63	41	20	14
15	1768	1837	1906	1976	2046	2117	2190	2263	2337	2411	2487	2564	2642	2722	15
16	69	38	07	77	47	19	91	64	38	13	89	66	44	23	16
17	70	39	08	78	48	20	92	65	39	14	90	67	45	24	17
18	72	40	09	79	50	21	93	66	40	15	91	68	46	26	18
19	73	41	10	80	51	22	94	68	42	16	92	69	48	27	19
20	1774	1842	1912	1981	2052	2123	2196	2269	2343	2418	2494	2571	2649	2728	20
21	75	43	13	83	53	25	97	70	44	19	95	72	50	29	21
22	76	45	14	84	54	26	98	71	45	20	96	73	51	31	22
23	77	46	15	85	56	27	99	72	46	22	98	75	53	32	23
24	78	47	16	86	57	28	2200	74	48	23	99	76	54	33	24
25	1780	1848	1917	1987	2058	2129	2202	2275	2349	2424	2500	2577	2655	2735	25
26	81	49	18	88	59	31	03	76	50	25	01	78	57	36	26
27	82	50	20	90	60	32	04	77	51	27	03	80	58	37	27
28	83	52	21	91	61	33	05	79	53	28	04	81	59	39	28
29	84	53	22	92	63	34	07	80	54	29	05	82	61	40	29
30	1785	1854	1923	1993	2064	2135	2208	2281	2355	2430	2506	2584	2662	2742	30
31	86	55	24	94	65	37	09	82	56	32	08	85	63	43	31
32	87	56	25	95	66	38	10	83	58	33	09	86	65	44	32
33	89	57	27	97	67	39	11	85	59	34	10	88	66	46	33
34	90	58	28	98	69	40	13	86	60	35	12	89	67	47	34
35	1791	1860	1929	1999	2070	2141	2214	2287	2361	2437	2513	2590	2669	2748	35
36	92	61	30	2000	71	43	15	88	63	38	14	91	70	50	36
37	93	62	31	01	72	44	16	90	64	39	15	93	71	51	37
38	94	63	32	02	73	45	17	91	65	40	17	94	73	52	38
39	95	64	34	04	75	46	19	92	66	42	18	95	74	54	39
40	1797	1865	1935	2005	2076	2147	2220	2293	2368	2443	2519	2597	2675	2755	40
41	98	66	36	06	77	49	21	95	69	44	21	98	76	56	41
42	99	68	37	07	78	50	22	96	70	45	22	99	78	58	42
43	1800	69	38	08	79	51	24	97	71	47	23	2601	79	59	43
44	01	70	39	10	80	52	25	98	73	48	24	02	80	60	44
45	1802	1871	1941	2011	2082	2153	2226	2299	2374	2449	2526	2603	2682	2762	45
46	03	72	42	12	83	55	27	2301	75	51	27	04	83	63	46
47	05	73	43	13	84	56	28	02	76	52	28	06	84	64	47
48	06	75	44	14	85	57	30	03	78	53	30	07	86	66	48
49	07	76	45	15	86	58	31	04	79	54	31	08	87	67	49
50	1808	1877	1946	2017	2088	2159	2232	2306	2380	2456	2532	2610	2688	2768	50
51	09	78	48	18	89	61	33	07	81	57	33	11	90	70	51
52	10	79	49	19	90	62	35	08	83	58	35	12	91	71	52
53	11	80	50	20	91	63	36	09	84	59	36	14	92	72	53
54	13	81	51	21	92	64	37	11	85	61	37	15	94	74	54
55	1814	1883	1952	2022	2094	2165	2238	2312	2386	2462	2538	2616	2695	2775	55
56	15	84	53	24	95	67	39	13	88	63	40	17	96	76	56
57	16	85	55	25	96	68	41	14	89	64	41	19	98	78	57
58	17	86	56	26	97	69	42	16	90	66	42	20	99	79	58
59	18	87	57	27	98	70	43	17	91	67	44	21	2700	80	59
M.	28d.	29d.	30d.	31d.	32d.	33d.	34d.	35d.	36d.	37d.	38d.	39d.	40d.	41d.	M.

Right Ascensions and Declinations of some of the principal fixed Stars, adapted to the beginning of the year 1820, with their annual variations.

Names and situations of the STARS.	Characters.	Magnitudes.	Right Ascension.	Ann. Var. R. A. add after 1820.	Declination.	Annual Variation.
			H. M. S.	″	° ′	″
The Lesser Dog, *Procyon*	α	1.2	7.29.52	3.15	5.41 N.	— 8.5
* In the head of the southern Twin, Pollux	β	1.2	7.34.17	3.69	28.27 N.	— 8.0
In the row lock of the ship Argo	ζ	2	7.57.16	2.12	39.30 S.	+ 9.7
In the poop of the sl o	γ	2	8. 4. 1	1.86	46.48 S.	+10.3
In the middle	δ	2 3	8.39.45	1.66	54. 8 S.	+12.9
In the oars of the shi	β	2.3	9.11.13	0.75	68.59 S.	+14.9
The heart of the fer dra *Alphard*	α	2	9.18.44	2.95	7.53 S.	+15.2
* The Lion's heart Regulus	α	1.2	9.58.46	3.21	12.51 N.	—17.3
South pointer in the sq. of the Great Bear	β	2	10,50.54	3.71	57.21 N.	—19.1
in the sq. of the	α	1.2	10.52.32	3.83	62.43 N.	—19.3
	β	1.2	11.39.52	3.07	15.35 N.	—20.0
S. E. Star of □ of the Great Bear	γ	2	11.44.19	3.20	54.42 N.	—20.0
N. E. Star of □ of the Great Bear	δ	3	12. 6.27	3.02	58. 2 N.	—20.1
In the foot of the Cross	[illegible]	1	12.16.41	3.24	62. 6 S.	+20.0
In the top of the Cross	γ	2	12.21.13	3.24	56. 6 S.	+20.0
In the following arm of the Cross	β	2	12.37.18	3.41	58.41 S.	+19.8
Alioth, first Star in the tail of the Great Bear	ε	2.3	12.46. 8	2.75	56.56 N.	—19.7
* The Virgin's spike—Spica	α	1	13.15.43	3.14	10.13 S.	+19.0
The second Star in the tail of the Great Bear	ζ	2.3	13.16.39	2.43	55.52 N.	—10.0
	η	2	13.40.26	2.38	50.19 N.	—18.2
foot of the Centaur	β	2	13.51.14	4.10	59.30 S.	+17.9
In the tail of the Dragon	α	2.3	13.59.31	[illegible]	65.14 N.	—17.4
The bright Star in Bootes—*Arcturus*	α	1	14. 7.26	2.73	20. 8 N.	—19.0
The eastern foot of the Centaur	α	1	14.28. 0	4.44	60. 7 S.	—16.1
The southern scale of the balance	α	2.3	14.40.56	3.29	15.17 S.	+15.2
The northern scale of the balance	β	2.3	15. 7.20	3.22	8.48 S.	+13.8
Bright Star in the Crown *Gemma*	α	2	15.27. 4	[illegible]	27.20 N.	—12.5

CORRECTION.

CORRECTION.

TABLE XIX.

CORRECTION.

CORRECTION.

... continued.

Correction Formulae	Reciprocal of Ratio	Correction for Size
[illegible]	[illegible]	[illegible]

S.	Cor.
1	2
	2
2	1
3	1
4	1
5	1
6	1
7	1
8	1
9	1

S.	Cor.
1	12
2	10
3	7
4	5
5	5
6	3
7	3
8	2
9	1

S.	Cor.
0	15

CORRECTION.

correction and logarithm?

For the Correction.

In Tab. xix. to alt. 7[illegible] [illegible]′ and par. 56′ is	46′ 37″
.. Tab. A. [illegible]″ parallax . . .	10
.. Tab. B. 6′ altitude . . .	6
Sought correction .	46′ 53″

For the Logarithm.

In Tab. xix. to nearest alt. 7[illegible]° and par. 56′ 10″	2110
.. Tab. C. [illegible]″ parallax . .	2
Sought logarithm . . .	2112

EXAMPLE V.

Given the moon's apparent altitude 16° 25′ and her horizontal parallax 58′ 45″. Required the correction and logarithm?

For the Correction.

In Tab. xix. to alt. 16° 20′ and par. 58′ is	6′ 17″
.. Tab. A. 45″ parallax . .	11
.. Tab. B. 5′ altitude . . .	0
Sought correction . .	6′ 28″

For the Logarithm.

Tab. xix. to nearest alt. 16° 20′ and par. 58′ 40″ is	2099
Tab. C. 5″ parallax . . .	6
Sought logarithm	2105

TABLE XIX.

CORRECTION.

App. alt. ☽		☽'s Horizontal Parallax.								Table A. Propor. part for Sec. of Par. Add.											Tab. B For M of alt. Add.	
D	M	54	55	56	57	58	59	60	61	S	0	1	2	3	4	5	6	7	8	9	M	S
50	0	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	49.27	49.17	[illegible]	0	10	10	10	10	9	9	9	9	9	9	[illegible]	[illegible]
	10	[illegible]	50.15	[illegible]	[illegible]	49.47	49.37	49.27	49.17	10	8	8	8	[illegible]	8	8	7	7	7	7		
	20	[illegible]	50.27	50.17	50. 7	49.57	49.47	49.37	49.27	20	7	7	6	6	6	6	6	6	5	5		
	30	50.47	50.37	50.27	50.17	50. 7	49.57	49.47	[illegible]	30	5	5	5	5	4	4	4	4	4	4		
	40	[illegible]	[illegible]	[illegible]	[illegible]	50.17	50. 7	49.57	[illegible]	40	3	3	3	3	3	3	2	2	2	2		
	50	[illegible]	[illegible]	[illegible]	[illegible]	50.27	50.17	[illegible]	[illegible]	50	2	2	1	1	1	1	1	1	0	0		
51	0	51.15	51. 6	[illegible]	50.47	50.37	[illegible]	50.19	50. 9	0	9	9	9	9	8	8	8	8	8	8	[illegible]	[illegible]
	10	51.24	51.15	51. 6	50.57	50.47	[illegible]	[illegible]	50.20	10	8	7	7	7	7	7	7	6	6	6		
	20	[illegible]	51.24	51.15	51. 6	50.57	50.48	50.39	50.30	20	6	6	6	6	5	5	5	5	5	5		
	30	51.42	51.34	51.25	51.16	51. 7	[illegible]	50.49	50.40	30	5	4	4	4	4	4	4	[illegible]	3	3		
	40	51.52	51.43	51.34	51.26	51.17	51. 8	50.59	50.51	40	3	3	3	3	2	2	2	2	2	2		
	50	52. 1	51.52	51.44	[illegible]	51.27	[illegible]	51.10	51. 1	50	2	1	1	1	1	1	1	0	0	0		
52	0	52.11	52. 3	51.54	51.46	[illegible]	[illegible]	51.21	[illegible]	0	8	8	8	8	7	7	7	7	7	7	[illegible]	[illegible]
	10	52.20	52.12	52. 4	51.56	51.47	51.39	51.31	51.23	10	7	7	6	6	6	6	6	6	6	5		
	20	52.29	52.21	52.13	52. 5	51.57	51.49	51.41	51.33	20	5	5	5	5	5	5	5	4	4	4		
	30	52.39	52.31	52.23	52.15	52. 7	51.59	51.52	51.44	30	4	4	4	4	4	3	3	3	3	3		
	40	52.48	52.40	52.32	52.25	52.17	52. 9	52. 2	51.54	40	3	3	2	2	2	2	2	2	2	2		
	50	52.57	52.49	52.42	52.34	52.27	52.19	52.12	52. 4	50	1	1	1	1	1	1	1	0	0	0		
53	0	53. 7	53. 0	52.52	52.45	52.37	52.30	52.23	52.16	0	7	7	7	7	7	6	6	6	6	6	[illegible]	[illegible]
	10	53.16	53. 9	53. 2	52.55	52.48	52.41	52.33	52.26	10	6	6	6	6	5	5	5	5	5	5		
	20	53.25	53.18	53.11	53. 5	[illegible]	52.51	52.44	52.37	20	5	5	4	4	4	4	4	4	4	4		
	30	53.35	53.28	53.21	53.14	53. 7	53. 1	52.54	52.47	30	4	3	3	3	3	3	3	3	3	3		
	40	53.44	53.37	53.31	53.24	53.17	53.11	53. 4	52.57	40	2	2	2	2	2	2	2	2	1	1		
	50	53.53	53.47	53.40	53.34	53.27	53.21	53.14	53. 8	50	1	1	1	1	1	1	1	0	0	0		
84	0	54. 3	53.57	53.51	53.44	53.38	53.32	53.26	53.19	0	6	6	6	6	6	6	5	5	5	5	[illegible]	[illegible]
	10	54.12	54. 6	54. 0	53.54	53.48	53.42	53.36	53.30	10	5	5	5	5	5	4	4	4	4	4		
	20	54.22	54.16	54.10	54. 4	53.58	53.52	53.46	53.40	20	4	4	4	4	4	3	3	3	3	3		
	30	54.31	54.25	54.19	54.14	54. 8	54. 2	53.56	53.51	30	3	3	3	3	3	2	2	2	2	2		
	40	54.40	54.35	54.29	54.23	54.18	54.12	54. 7	54. 1	40	2	2	2	2	2	2	2	1	1	1		
	50	54.49	54.44	54.39	54.33	54.28	54.22	54.17	54.11	50	1	1	1	1	1	1	1	0	0	0		
85	0	55. 0	54.54	54.49	54.44	54.39	54.33	54.28	54.23	0	5	5	5	5	5	5	5	4	4	4	[illegible]	[illegible]
	10	55. 9	55. 4	54.59	54.54	54.49	54.43	54.38	54.33	10	4	4	4	4	4	4	4	4	4	3		
	20	55.18	55.13	55. 8	55. 3	54.58	54.54	54.49	54.44	20	3	3	3	3	3	3	3	3	3	3		
	30	55.27	55.23	55.18	55.13	55. 8	55. 4	54.59	54.54	30	3	3	2	2	2	2	2	2	2	2		
	40	55.36	55.32	55.27	55.23	55.18	55.14	55. 9	55. 5	40	2	2	2	2	1	1	1	1	1	1		
	50	55.46	55.41	55.37	55.33	55.28	55.24	55.20	55.15	50	1	1	1	1	1	1	1	0	0	0		
86	0	55.56	55.52	55.48	55.43	55.39	55.35	55.31	55.27	0	4	4	4	4	4	4	4	4	4	3	[illegible]	[illegible]
	10	56. 5	56. 1	55.57	55.53	55.49	55.45	55.41	55.37	10	3	3	3	3	3	3	3	3	3	3		
	20	56.11	56.11	56. 7	56. 3	55.59	55.55	55.52	55.48	20	3	3	3	3	3	2	2	2	2	2		
	30	56.24	56.20	56.16	56.13	56. 9	56. 5	56. 2	55.58	30	2	2	2	2	2	2	2	2	2	2		
	40	56.33	56.29	56.26	56.22	56.19	56.15	56.12	56. 8	40	2	1	1	1	1	1	1	1	1	1		
	50	56.42	56.39	56.36	56.32	56.29	56.26	56.22	56.19	50	1	1	1	1	1	1	1	0	0	0		
87	0	56.52	56.49	56.46	56.43	56.40	56.37	56.34	56.30	0	3	3	3	3	3	3	3	3	3	3	[illegible]	[illegible]
	10	57. 2	56.59	56.56	56.53	56.50	56.47	56.44	56.41	10	3	3	2	2	2	2	2	2	2	2		
	20	57.11	57. 8	57. 5	57. 3	57. 0	56.57	56.54	56.51	20	2	2	2	2	2	2	2	2	2	2		
	30	57.20	57.18	57.15	57.12	57.10	57. 7	57. 4	57. 2	30	2	2	2	2	1	1	1	1	1	1		
	40	57.29	57.27	57.25	57.22	57.20	57.17	57.15	57.12	40	1	1	1	1	1	1	1	1	1	1		
	50	57.39	57.36	57.34	57.32	57.30	57.27	57.25	57.23	50	1	1	1	1	1	1	0	0	0	0		
88	0	57.49	57.47	57.45	57.43	57.41	57.38	57.36	57.34	0	2	2	2	2	2	2	2	2	2	2	[illegible]	[illegible]
	10	57.58	57.56	57.54	57.52	57.50	57.49	57.47	57.45	10	2	2	2	2	2	2	2	2	2	1		
	20	58. 7	58. 6	58. 4	58. 2	58. 0	57.59	57.57	57.55	20	1	1	1	1	1	1	1	1	1	1		
	30	58.17	58.15	58.14	58.12	58.10	58. 9	58. 7	58. 6	30	1	1	1	1	1	1	1	1	1	1		
	40	58.26	58.25	58.23	58.22	58.20	58.19	58.18	58.16	40	1	1	1	1	1	1	1	1	1	1		
	50	58.35	58.34	58.33	58.32	58.30	58.29	58.28	58.27	50	1	1	1	1	1	0	0	0	0	0		
89	0	58.45	58.44	58.43	58.42	58.41	58.40	58.39	58.38	0	1	1	1	1	1	1	1	1	1	1	[illegible]	[illegible]
	10	58.55	58.54	58.53	58.52	58.51	58.50	58.49	58.49	10	1	1	1	1	1	1	1	1	1	1		
	20	59. 4	59. 3	59. 3	59. 2	59. 1	59. 0	58.59	58.59	20	1	1	1	1	1	1	1	1	1	1		
	30	59.13	59.13	59.12	59.12	59.11	59.11	59.10	59.10	30	1	1	1	1	1	1	1	1	1	1		
	40	59.22	59.22	59.22	59.21	59.21	59.21	59.20	59.20	40	1	1	1	1	1	1	1	1	1	1		
	50	59.32	59.32	59.31	59.31	59.31	59.31	59.31	59.31	50	1	1	1	1	1	0	0	0	0	0		

TABLE XX.

Corr. Tab. 19	Corr. Tab. 19 + 2 Cr.	Apparent Distance. 10° Tab.19.	10° Tab.19. +2Cor	11° Tab.19.	11° Tab.19. +2Cor	12° Tab.19.	12° Tab.19. +2Cor	13° Tab.19.	13° Tab.19. +2Cor	14° Tab.19.	14° Tab.19. +2Cor	15° Tab.19.	15° Tab.19. +2Cor
M	M.	"	"	"	"	"	"	"	"	"	"	"	"
0	120	196	178	179	161	166	148	154	136	144	126	135	117
1	119	190	172	174	156	161	143	149	131	140	122	131	113
2	118	184	166	169	151	156	138	145	127	136	118	127	109
3	117	178	160	164	146	151	133	141	123	[illegible]	114	124	106
4	116	173	155	159	141	147	129	136	118	[illegible]	110	120	102
5	115	167	149	154	136	142	124	132	114	124	106	116	98
6	114	162	144	149	131	138	120	128	110	120	102	113	95
7	113	157	139	144	126	133	115	124	106	116	98	109	91
8	112	152	134	139	121	129	111	120	102	113	95	106	88
9	111	146	128	135	117	125	107	116	98	109	91	103	85
10	110	142	124	130	112	121	103	112	94	105	87	99	81
11	109	137	119	126	108	116	98	109	91	102	84	96	78
12	108	132	114	121	103	112	94	105	87	99	81	93	75
13	107	127	109	117	99	109	91	101	83	95	77	90	72
14	106	123	105	113	95	105	87	98	80	92	74	87	69
15	105	118	100	109	91	101	83	94	76	89	71	84	66
16	104	114	96	105	87	97	79	91	73	86	68	81	63
17	103	109	91	101	83	94	76	88	70	83	65	78	60
18	102	105	87	97	79	90	72	85	67	80	62	75	57
19	101	101	83	93	75	87	69	81	63	77	59	73	55
20	100	97	79	90	72	84	66	78	60	74	56	70	52
21	99	93	75	86	68	80	62	75	57	71	53	68	50
22	98	89	71	83	65	77	59	73	55	69	51	65	47
23	97	86	68	79	61	74	56	70	52	66	48	63	45
24	96	82	64	76	58	71	53	67	49	63	45	60	42
25	95	79	61	73	55	68	50	64	46	61	43	58	40
26	94	75	57	70	52	65	47	62	44	58	40	56	38
27	93	72	54	67	49	63	45	59	41	56	38	53	35
28	92	69	51	64	46	60	42	57	39	54	36	51	33
29	91	66	48	61	43	57	39	54	36	52	34	49	31
30	90	63	45	58	40	55	37	52	34	49	31	47	29
31	89	60	42	56	38	53	35	50	32	47	29	45	27
32	88	57	39	53	35	50	32	48	30	45	27	44	26
33	87	54	36	51	33	48	30	46	28	44	26	42	24
34	86	51	33	48	30	46	28	44	26	42	24	40	22
35	85	49	31	46	28	44	26	42	24	40	22	38	20
36	84	46	28	44	26	42	24	40	22	38	20	37	19
37	83	44	26	42	24	40	22	38	20	37	19	35	17
38	82	42	24	40	22	38	20	36	18	35	17	34	16
39	81	40	22	38	20	36	18	35	17	33	15	32	14
40	80	38	20	36	18	34	16	33	15	32	14	31	13
41	79	36	18	34	16	33	15	32	14	31	13	30	12
42	78	34	16	33	15	31	13	30	12	29	11	29	11
43	77	32	14	31	13	30	12	29	11	28	10	27	9
44	76	31	13	29	11	29	11	28	10	27	9	26	8
45	75	29	11	28	10	27	9	27	9	26	8	25	7
46	74	28	10	27	9	26	8	25	7	25	7	24	6
47	73	26	8	26	8	25	7	24	6	24	6	24	6
48	72	25	7	24	6	24	6	23	5	23	5	23	5
49	71	24	6	23	5	23	5	23	5	22	4	22	4
50	70	23	5	22	4	22	4	22	4	21	3	21	3
52	68	21	3	21	3	21	3	20	2	20	2	20	2
55	65	19	1	19	1	19	1	19	1	19	1	19	1
60	60	18	0	13	0	18	0	18	0	18	0	18	0
		Tab.19.	Tab.19. +2Cor	Tab.19.	Tab.19. +2Cor	Tab.19.	Tab.19. +2Cor	Tab.19.	Tab.19. +2Cor	Tab.19.	Tab.19. +2Cor	Tab.19.	Tab.19. +2Cor
		10°		11°		12°		13		14°		15°	

TABLE XX.

[illegible]

[illegible]

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TABLE XXII.

PROPORTIONAL LOGARITHMS.

S.	h m 0-54	h m 0-55	h m 0-56	h m 0-57	h m 0-58	h m 0-59	h m 1-0	h m 1-1	h m 1-2	h m 1-3	h m 1-4	h m 1-5	S.
0	5229	5149	5071	4994	4918	4844	4771	4699	4629	4559	4491	4424	0
1	5227	5148	5070	4993	4917	4843	4770	4698	4628	4558	4490	4422	1
2	5226	5146	5068	4991	4916	4842	4769	4697	4626	4557	4489	4421	2
3	5225	5145	5067	4990	4915	4841	4768	4696	4625	4556	4488	4420	3
4	5223	5144	5066	4989	4913	4839	4766	4695	4624	4555	4486	4419	4
5	5222	5143	5064	4988	4912	4838	4765	4693	4623	4554	4485	4418	5
6	5221	5141	5063	4986	4911	4837	4764	4692	4622	4552	4484	4417	6
7	5219	5140	5062	4985	4910	4836	4763	4691	4621	4551	4483	4416	7
8	5218	5139	5061	4984	4909	4834	4762	4690	4619	4550	4482	4415	8
9	5217	5137	5059	4983	4907	4833	4760	4689	4618	4549	4481	4414	9
10	5215	5136	5058	4981	4906	4832	4759	4688	4617	4548	4480	4412	10
11	5214	5135	5057	4980	4905	4831	4758	4686	4616	4547	4479	4411	11
12	5213	5133	5055	4979	4903	4830	4757	4685	4615	4546	4477	4410	12
13	5211	5132	5054	4977	4902	4828	4756	4684	4614	4544	4476	4409	13
14	5210	5131	5053	4976	4901	4827	4754	4683	4612	4543	4475	4408	14
15	5209	5129	5051	4975	4900	4826	4753	4682	4611	4542	4474	4407	15
16	5207	5128	5050	4974	4899	4825	4752	4680	4610	4541	4473	4406	16
17	5206	5127	5049	4972	4897	4823	4751	4679	4609	4540	4472	4405	17
18	5205	5125	5048	4971	4896	4822	4750	4678	4608	4539	4471	4404	18
19	5203	5124	5046	4970	4895	4821	4748	4677	4607	4538	4469	4402	19
20	5202	5123	5045	4969	4894	4820	4747	4676	4606	4536	4468	4401	20
21	5201	5122	5044	4967	4892	4819	4746	4675	4604	4535	4467	4400	21
22	5199	5120	5043	4966	4891	4817	4745	4673	4603	4534	4466	4399	22
23	5198	5119	5041	4965	4890	4816	4744	4672	4602	4533	4465	4398	23
24	5197	5118	5040	4964	4889	4815	4742	4671	4601	4532	4464	4397	24
25	5195	5116	5039	4962	4887	4814	4741	4670	4600	4531	4463	4396	25
26	5194	5115	5037	4961	4886	4812	4740	4669	4599	4530	4462	4395	26
27	5193	5114	5036	4960	4885	4811	4739	4668	4597	4528	4460	4394	27
28	5191	5112	5035	4959	4884	4810	4738	4666	4596	4527	4459	4393	28
29	5190	5111	5934	4957	4882	4809	4736	4665	4595	4526	4458	4391	29
30	5189	5110	5032	4956	4881	4808	4735	4664	4594	4525	4457	4390	30
31	5187	5103	5031	4955	4880	4806	4734	4663	4593	4524	4456	4389	31
32	5186	5107	5030	4954	4879	4805	4733	4662	4592	4523	4455	4388	32
33	5135	5106	5028	4952	4877	4804	4732	4660	4590	4622	4454	4387	33
34	5183	5105	5927	4951	4876	4803	4730	4659	4589	4520	4453	4386	34
35	5182	5103	5026	4950	4875	4801	4729	4658	4588	4519	4452	4385	35
36	5181	5102	5025	4949	4874	4800	4728	4657	4587	4518	4450	4384	36
37	5179	5101	5023	4947	4873	4799	4727	4656	4586	4517	4419	4383	37
38	5178	5099	5022	4946	4871	4798	4726	4655	4585	4516	4418	4331	38
39	5177	5998	5021	4945	4870	4797	4724	4653	4584	4515	4447	4380	39
40	5175	5097	5019	4943	4869	4796	4723	4652	4582	4514	4446	4379	40
41	5174	5095	5018	4942	4868	4794	4722	4651	4581	4512	4445	4378	41
42	5173	5094	5017	4941	4866	4793	4721	4650	4580	4511	4444	4377	42
43	5172	5093	5016	4949	4865	4792	4720	4649	4579	4510	4443	4376	43
44	5170	5092	5014	4938	4864	4791	4718	4648	4578	4509	4441	4375	44
45	5169	5090	5013	4937	4863	4789	4717	4646	4577	4508	4110	4374	45
46	5168	5089	5012	4936	4861	4788	4716	4645	4575	4507	4439	4373	46
47	5166	5088	5011	4935	4860	4787	4715	4644	4574	4506	4438	4372	47
48	5165	5086	5009	4933	4859	4786	4714	4643	4573	4505	4437	4370	48
49	5164	5085	5008	4932	4858	4785	4712	4642	4572	4503	4436	4369	49
50	5162	5084	5007	4931	4856	4783	4711	4640	4571	4502	4435	4368	50
51	5161	5082	5005	4930	4855	4782	4710	4639	4570	4501	4434	4367	51
52	5160	5081	5004	4928	4854	4781	4709	4638	4569	4500	4433	4366	52
53	5159	5080	5003	4927	4853	4780	4708	4637	4567	4499	4431	4365	53
54	5157	5079	5002	4926	4852	4778	4707	4636	4566	4498	4430	4364	54
55	5156	5077	5000	4925	4850	4777	4705	4635	4565	4497	4429	4363	55
56	5154	5076	4999	4923	4849	4776	4704	4633	4561	4495	4428	4362	56
57	5153	5075	4998	4922	4848	4775	4703	4632	4563	4494	4427	4361	57
58	5152	5073	4997	4921	4847	4774	4702	4631	4562	4493	4426	4359	58
59	5150	5072	4996	4920	4845	4772	4701	4630	4560	4492	4425	4358	59
S.	0 54	0 55	0 56	0 57	0 58	0 59	1 0	1 1	1 2	1 3	1 4	1 5	S.

PROPORTIONAL LOGARITHMS.

S.	h m 1° 18′	h m 1° 19′	h m 1° 20′	h m 1° 21′	h m 1° 22′	h m 1° 23′	h m 1° 24′	h m 1° 25′	h m 1° 26′	h m 1° 27′	h m 1° 28′	h m 1° 29′	S.
0	3632	3576	3522	3468	3415	3362	3310	3259	3208	3158	3108	3059	0
1	3631	3576	3521	3467	3414	3361	3309	3258	3207	3157	3107	3058	1
2	3630	3575	3520	3466	3413	3360	3308	3257	3206	3156	3106	3057	2
3	3629	3574	3519	3465	3412	3359	3307	3256	3205	3155	3105	3056	3
4	3628	3573	3518	3464	3411	3358	3306	3255	3204	3154	3105	3056	4
5	3627	3572	3517	3463	3410	3358	3306	3254	3204	3153	3104	3055	5
6	3626	3571	3516	3463	3409	3357	3305	3253	3203	3153	3103	3054	6
7	3625	3570	3515	3462	3408	3356	3304	3253	3202	3152	3102	3053	7
8	3624	3569	3515	3461	3408	3355	3303	3252	3201	3151	3101	3052	8
9	3623	3568	3514	3460	3407	3354	3302	3251	3200	3150	3101	3052	9
10	3623	3567	3513	3459	3406	3353	3301	3250	3199	3149	3100	3051	10
11	3622	3566	3512	3458	3405	3352	3300	3249	3198	3148	3099	3050	11
12	3621	3565	3511	3457	3404	3351	3300	3248	3198	3148	3098	3049	12
13	3620	3565	3510	3456	3403	3351	3299	3247	3197	3147	3097	3048	13
14	3619	3564	3509	3455	3402	3350	3298	3247	3196	3146	3096	3047	14
15	3618	3563	3508	3454	3401	3349	3297	3246	3195	3145	3096	3047	15
16	3617	3562	3507	3454	3400	3348	3296	3245	3194	3144	3095	3046	16
17	3616	3561	3506	3453	3400	3347	3295	3244	3193	3143	3094	3045	17
18	3615	3560	3505	3452	3399	3346	3294	3243	3193	3143	3093	3044	18
19	3614	3559	3505	3451	3398	3345	3294	3242	3192	3142	3092	3043	19
20	3613	3558	3504	3450	3397	3345	3293	3242	3191	3141	3091	3043	20
21	3612	3557	3503	3449	3396	3344	3292	3241	3190	3140	3091	3042	21
22	3611	3556	3502	3448	3395	3343	3291	3240	3189	3139	3090	3041	22
23	3610	3555	3501	3447	3394	3342	3290	3239	3188	3138	3089	3040	23
24	3610	3555	3500	3446	3393	3341	3289	3238	3188	3138	3088	3039	24
25	3609	3554	3499	3446	3393	3340	3288	3237	3187	3137	3087	3039	25
26	3608	3553	3498	3445	3392	3339	3288	3236	3186	3136	3087	3038	26
27	3607	3552	3497	3444	3391	3338	3287	3236	3185	3135	3086	3037	27
28	3606	3551	3497	3443	3390	3338	3286	3235	3184	3134	3085	3036	28
29	3605	3550	3496	3442	3389	3337	3285	3234	3183	3133	3084	3035	29
30	3604	3549	3495	3441	3388	3336	3284	3233	3183	3133	3083	3034	30
31	3603	3548	3494	3440	3387	3335	3283	3232	3182	3132	3082	3034	31
32	3602	3547	3493	3439	3386	3334	3282	3231	3181	3131	3082	3033	32
33	3601	3546	3492	3438	3386	3333	3282	3231	3180	3130	3081	3032	33
34	3600	3545	3491	3438	3385	3332	3281	3230	3179	3129	3080	3031	34
35	3599	3545	3490	3437	3384	3332	3280	3229	3178	3129	3079	3030	35
36	3598	3544	3489	3436	3383	3331	3279	3228	3178	3128	3078	3030	36
37	3598	3543	3488	3435	3382	3330	3278	3227	3177	3127	3078	3029	37
38	3597	3542	3488	3434	3381	3329	3277	3226	3176	3126	3077	3028	38
39	3596	3541	3487	3433	3380	3328	3276	3225	3175	3125	3076	3027	39
40	3595	3540	3486	3432	3379	3327	3276	3225	3174	3124	3075	3026	40
41	3594	3539	3485	3431	3379	3326	3275	3224	3173	3124	3074	3026	41
42	3593	3538	3484	3431	3378	3325	3274	3223	3173	3123	3073	3025	42
43	3592	3537	3483	3430	3377	3325	3273	3222	3172	3122	3073	3024	43
44	3591	3536	3482	3429	3376	3324	3272	3221	3171	3121	3072	3023	44
45	3590	3535	3481	3428	3375	3323	3271	3220	3170	3120	3071	3022	45
46	3589	3535	3480	3427	3374	3322	3270	3220	3169	3119	3070	3022	46
47	3588	3534	3480	3426	3373	3321	3270	3219	3168	3119	3069	3021	47
48	3587	3533	3479	3425	3372	3320	3269	3218	3168	3118	3069	3020	48
49	3587	3532	3478	3424	3372	3319	3268	3217	3167	3117	3068	3019	49
50	3586	3531	3477	3423	3371	3319	3267	3216	3166	3116	3067	3018	50
51	3585	3530	3476	3423	3370	3318	3266	3215	3165	3115	3066	3018	51
52	3584	3529	3475	3422	3369	3317	3265	3214	3164	3114	3065	3017	52
53	3583	3528	3474	3421	3368	3316	3265	3214	3163	3114	3065	3016	53
54	3582	3527	3473	3420	3367	3315	3264	3213	3163	3113	3064	3015	54
55	3581	3526	3472	3419	3366	3314	3263	3212	3162	3112	3063	3014	55
56	3580	3525	3471	3418	3365	3313	3262	3211	3161	3111	3062	3014	56
57	3579	3525	3471	3417	3365	3313	3261	3210	3160	3110	3061	3013	57
58	3578	3524	3470	3416	3364	3312	3260	3209	3159	3110	3060	3012	58
59	3577	3523	3469	3415	3363	3311	3259	3209	3158	3109	3060	3011	59
S.	1° 18′	1° 19′	1° 20′	1° 21′	1° 22′	1° 23′	1° 24′	1° 25′	1° 26′	1° 27′	1° 28′	1° 29′	S.

PROPORTIONAL LOGARITHMS.

S.	h m 1° 30′	h m 1° 31′	h m 1° 32′	h m 1° 33′	h m 1° 34′	h m 1° 35′	h m 1° 36′	h m 1° 37′	h m 1° 38′	h m 1° 39′	h m 1° 40′	h m 1° 41′	S.
0	3010	2962	2915	2868	2821	2775	2730	2685	2640	2596	2553	2510	0
1	3009	2962	2914	2867	2821	2775	2729	2684	2640	2596	2552	2509	1
2	3009	2961	2913	2866	2820	2774	2729	2684	2639	2595	2551	2508	2
3	3008	2960	2912	2866	2819	2773	2728	2683	2638	2594	2551	2507	3
4	3007	2959	2912	2865	2818	2772	2727	2682	2638	2593	2550	2507	4
5	3006	2958	2911	2864	2818	2772	2726	2681	2637	2593	2549	2506	5
6	3005	2958	2910	2863	2817	2771	2725	2681	2636	2592	2548	2505	6
7	3005	2957	2909	2862	2816	2770	2725	2680	2635	2591	2548	2504	7
8	3004	2956	2909	2862	2815	2769	2724	2679	2635	2591	2547	2504	8
9	3003	2955	2908	2861	2815	2769	2723	2678	2634	2590	2546	2503	9
10	3002	2954	2907	2860	2814	2768	2722	2678	2633	2589	2545	2502	10
11	3001	2954	2906	2859	2813	2767	2722	2677	2632	2588	2545	2502	11
12	3001	2953	2905	2859	2812	2766	2721	2676	2632	2588	2544	2501	12
13	3000	2952	2905	2858	2811	2766	2720	2675	2631	2587	2543	2500	13
14	2999	2951	2904	2857	2811	2765	2719	2675	2630	2586	2543	2499	14
15	2998	2950	2903	2856	2810	2764	2719	2674	2629	2585	2542	2499	15
16	2997	2950	2902	2855	2809	2763	2718	2673	2629	2585	2541	2498	16
17	2997	2949	2901	2855	2808	2763	2717	2672	2628	2584	2540	2497	17
18	2996	2948	2901	2854	2808	2762	2716	2672	2627	2583	2540	2497	18
19	2995	2947	2900	2853	2807	2761	2716	2671	2626	2583	2539	2496	19
20	2994	2946	2899	2852	2806	2760	2715	2670	2626	2582	2538	2495	20
21	2993	2946	2898	2852	2805	2760	2714	2669	2625	2581	2538	2494	21
22	2993	2945	2898	2851	2805	2759	2713	2669	2624	2580	2537	2494	22
23	2992	2944	2897	2850	2804	2758	2713	2668	2624	2580	2536	2493	23
24	2991	2943	2896	2849	2803	2757	2712	2667	2623	2579	2535	2492	24
25	2990	2942	2895	2848	2802	2756	2711	2666	2622	2578	2535	2492	25
26	2989	2942	2894	2848	2801	2756	2710	2666	2621	2577	2534	2491	26
27	2989	2941	2894	2847	2801	2755	2710	2665	2621	2577	2533	2490	27
28	2988	2940	2893	2846	2800	2754	2709	2664	2620	2576	2533	2489	28
29	2987	2939	2892	2845	2799	2753	2708	2663	2619	2575	2532	2489	29
30	2986	2939	2891	2845	2798	2753	2707	2663	2618	2574	2531	2488	30
31	2985	2938	2891	2844	2798	2752	2707	2662	2618	2574	2530	2487	31
32	2985	2937	2890	2843	2797	2751	2706	2661	2617	2573	2530	2487	32
33	2984	2936	2889	2842	2796	2750	2705	2660	2616	2572	2529	2486	33
34	2983	2935	2888	2842	2795	2750	2704	2660	2615	2572	2528	2485	34
35	2982	2935	2887	2841	2795	2749	2704	2659	2615	2571	2527	2485	35
36	2981	2934	2887	2840	2794	2748	2703	2658	2614	2570	2527	2484	36
37	2981	2933	2886	2839	2793	2747	2702	2657	2613	2569	2526	2483	37
38	2980	2932	2885	2838	2792	2747	2701	2657	2612	2569	2525	2482	38
39	2979	2931	2884	2838	2792	2746	2701	2656	2612	2568	2525	2482	39
40	2978	2931	2883	2837	2791	2745	2700	2655	2611	2567	2524	2481	40
41	2977	2930	2883	2836	2790	2744	2699	2655	2610	2566	2523	2480	41
42	2977	2929	2882	2835	2789	2744	2698	2654	2610	2566	2522	2480	42
43	2976	2928	2881	2835	2788	2743	2698	2653	2609	2565	2522	2479	43
44	2975	2927	2880	2834	2788	2742	2697	2652	2608	2564	2521	2478	44
45	2974	2927	2880	2833	2787	2741	2696	2652	2607	2564	2520	2477	45
46	2973	2926	2879	2832	2786	2741	2695	2651	2607	2563	2520	2477	46
47	2973	2925	2878	2831	2785	2740	2695	2650	2606	2562	2519	2476	47
48	2972	2924	2877	2831	2785	2739	2694	2649	2605	2561	2518	2475	48
49	2971	2924	2876	2830	2784	2738	2693	2649	2604	2561	2517	2475	49
50	2970	2923	2876	2829	2783	2738	2692	2648	2604	2560	2517	2474	50
51	2969	2922	2875	2828	2782	2737	2692	2647	2603	2559	2516	2473	51
52	2969	2921	2874	2828	2782	2736	2691	2646	2602	2559	2515	2472	52
53	2968	2920	2873	2827	2781	2735	2690	2646	2601	2558	2515	2472	53
54	2967	2920	2873	2826	2780	2735	2689	2645	2601	2557	2514	2471	54
55	2966	2919	2872	2825	2779	2734	2689	2644	2600	2556	2513	2470	55
56	2965	2918	2871	2825	2779	2733	2688	2643	2599	2556	2512	2470	56
57	2965	2917	2870	2824	2778	2732	2687	2643	2599	2555	2512	2469	57
58	2964	2916	2869	2823	2777	2732	2687	2642	2598	2554	2511	2468	58
59	2963	2916	2869	2822	2776	2731	2686	2641	2597	2553	2510	2467	59
S.	1° 30′	1° 31′	1° 32′	1° 33′	1° 34′	1° 35′	1° 36′	1° 37′	1° 38′	1° 39′	1° 40′	1° 41′	S.

PROPORTIONAL LOGARITHMS.

S.	h m 2 49	h m 2 50	h m 2 51	h m 2 52	h m 2 53	h m 2 54	h m 2 55	h m 2 56	h m 2 57	h m 2 58	h m 2 59	S.
0	0274	0248	0222	0197	0172	0147	0122	0098	0073	0049	0024	0
1	0273	0248	0222	0197	0172	0147	0122	0097	0073	0048	0024	1
2	0273	0247	0222	0197	0171	0146	0122	0097	0072	0048	0023	2
3	0273	0247	0221	0196	0171	0146	0121	0096	0072	0047	0023	3
4	0272	0247	0221	0196	0171	0146	0121	0096	0071	0047	0023	4
5	0272	0246	0221	0195	0170	0145	0120	0096	0071	0046	0022	5
6	0271	0246	0220	0195	0170	0145	0120	0095	0071	0046	0022	6
7	0271	0245	0220	0194	0169	0144	0119	0095	0070	0046	0021	7
8	0270	0245	0219	0194	0169	0144	0119	0094	0070	0045	0021	8
9	0270	0244	0219	0194	0169	0143	0119	0094	0069	0045	0021	9
10	0270	0244	0219	0193	0168	0143	0118	0093	0069	0044	0020	10
11	0269	0244	0218	0193	0168	0143	0118	0093	0068	0044	0020	11
12	0269	0243	0218	0192	0167	0142	0117	0093	0068	0044	0019	12
13	0268	0243	0217	0192	0167	0142	0117	0092	0068	0043	0019	13
14	0268	0242	0217	0192	0166	0141	0117	0092	0067	0043	0019	14
15	0267	0242	0216	0191	0166	0141	0116	0091	0067	0042	0018	15
16	0267	0241	0216	0191	0166	0141	0116	0091	0066	0042	0018	16
17	0267	0241	0215	0190	0165	0140	0115	0091	0066	0042	0017	17
18	0266	0241	0215	0190	0165	0140	0115	0090	0066	0041	0017	18
19	0266	0240	0215	0189	0164	0140	0114	0090	0065	0041	0017	19
20	0265	0240	0214	0189	0164	0139	0114	0089	0065	0040	0016	20
21	0265	0239	0214	0189	0164	0139	0114	0089	0064	0040	0016	21
22	0265	0239	0213	0188	0163	0138	0113	0089	0064	0040	0015	22
23	0264	0239	0213	0188	0163	0138	0113	0088	0064	0039	0015	23
24	0264	0238	0213	0187	0162	0137	0112	0088	0063	0039	0015	24
25	0263	0238	0212	0187	0162	0137	0112	0087	0063	0038	0014	25
26	0263	0237	0212	0187	0161	0136	0112	0087	0062	0038	0014	26
27	0262	0237	0211	0186	0161	0136	0111	0087	0062	0038	0013	27
28	0262	0236	0211	0186	0161	0136	0111	0086	0062	0037	0013	28
29	0261	0236	0211	0185	0160	0135	0110	0086	0061	0037	0012	29
30	0261	0235	0210	0185	0160	0135	0110	0085	0061	0036	0012	30
31	0261	0235	0210	0184	0159	0134	0110	0085	0060	0036	0012	31
32	0260	0235	0209	0184	0159	0134	0109	0084	0060	0036	0011	32
33	0260	0234	0209	0184	0158	0134	0109	0084	0060	0035	0011	33
34	0259	0234	0208	0183	0158	0133	0108	0084	0059	0035	0010	34
35	0259	0233	0208	0183	0158	0133	0108	0083	0059	0034	0010	35
36	0258	0233	0207	0182	0157	0132	0107	0083	0058	0034	0010	36
37	0258	0233	0207	0182	0157	0132	0107	0082	0058	0034	0009	37
38	0258	0232	0207	0181	0156	0131	0107	0082	0057	0033	0009	38
39	0257	0232	0206	0181	0156	0131	0106	0082	0057	0033	0008	39
40	0257	0231	0206	0181	0156	0131	0106	0081	0057	0032	0008	40
41	0256	0231	0205	0180	0155	0130	0105	0081	0056	0032	0008	41
42	0256	0230	0205	0180	0155	0130	0105	0080	0056	0031	0007	42
43	0255	0230	0205	0179	0154	0129	0105	0080	0055	0031	0007	43
44	0255	0230	0204	0179	0154	0129	0104	0080	0055	0031	0006	44
45	0255	0229	0204	0179	0153	0129	0104	0079	0055	0030	0006	45
46	0254	0229	0203	0178	0153	0128	0103	0079	0054	0030	0006	46
47	0254	0228	0203	0178	0153	0128	0103	0078	0054	0029	0005	47
48	0253	0228	0202	0177	0152	0127	0103	0078	0053	0029	0005	48
49	0253	0227	0202	0177	0152	0127	0102	0077	0053	0028	0004	49
50	0252	0227	0202	0176	0151	0126	0102	0077	0053	0028	0004	50
51	0252	0227	0201	0176	0151	0126	0101	0077	0052	0028	0004	51
52	0252	0226	0201	0176	0151	0126	0101	0076	0052	0027	0003	52
53	0251	0226	0200	0175	0150	0125	0101	0076	0051	0027	0003	53
54	0251	0225	0200	0175	0150	0125	0100	0075	0051	0027	0002	54
55	0250	0225	0200	0174	0149	0124	0100	0075	0051	0026	0002	55
56	0250	0224	0199	0174	0149	0124	0099	0075	0050	0026	0002	56
57	0250	0224	0199	0174	0149	0124	0099	0074	0050	0025	0001	57
58	0249	0224	0198	0173	0148	0123	0098	0074	0049	0025	0001	58
59	0249	0223	0198	0173	0148	0123	0098	0073	0049	0025	0000	59
S.	2 49	2 50	2 51	2 52	2 53	2 54	2 55	2 56	2 57	2 58	2 59	S.

TABLE [illegible]

[illegible]

′							′						
0	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	0	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
1	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	1	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
2	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	2	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
3	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	3	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
4	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	4	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
5	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	5	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
6	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	6	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
7	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	7	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
8	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	8	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
9	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	9	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
10	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	10	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
11	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	11	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
12	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	12	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
13	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	13	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
14	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	14	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
15	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	15	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
16	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	16	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
17	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	17	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
18	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	18	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
19	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	19	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
20	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	20	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
21	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	21	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
22	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	22	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
23	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	23	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
24	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	24	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
25	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	25	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
26	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	26	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
27	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	27	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
28	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	28	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
29	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	29	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
30	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	30	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
31	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	31	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
32	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	32	[illegible]	[illegible]	[illegible]	20409	[illegible]	[illegible]
33	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	33	[illegible]	[illegible]	20527	20551	[illegible]	[illegible]
34	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	34	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
35	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	09227	35	[illegible]	[illegible]	20807	[illegible]	[illegible]	[illegible]
36	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	36	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	21013
37	[illegible]	[illegible]	09022	[illegible]	[illegible]	[illegible]	37	[illegible]	21059	21081	21104	21126	21149
38	[illegible]	[illegible]	[illegible]	[illegible]	08842	08819	38	5.21172	21194	21217	21239	21261	21284
39	[illegible]	[illegible]	[illegible]	[illegible]	08708	08686	39	5.21306	21328	21351	21373	21395	21417
40	[illegible]	08641	08619	[illegible]	[illegible]	08553	40	5.21439	21462	21484	21506	21528	21550
41	[illegible]	08510	08488	08466	08444	08422	41	5.21572	21593	21615	21637	21659	21681
42	0.08401	08379	08357	08336	08314	08293	42	5.21702	21724	21746	21767	21789	21810
43	0.08271	08250	08228	08207	08185	08164	43	5.21832	21853	21875	21896	21918	21939
44	0.08143	08121	08100	08079	08058	08036	44	5.21960	21982	22003	22024	22045	22067
45	[illegible]	[illegible]	[illegible]	[illegible]	07931	07910	45	5.22088	22109	22130	22151	22172	22193
46	[illegible]	[illegible]	[illegible]	07827	07806	07785	46	5.22214	22235	22255	22276	22297	22318
47	[illegible]	[illegible]	[illegible]	[illegible]	07682	07661	47	5.22338	22359	22380	22400	22421	22442
48	0.07641	[illegible]	[illegible]	[illegible]	[illegible]	07539	48	5.22462	22483	22503	22524	22544	22564
49	0.07518	07498	[illegible]	[illegible]	07437	07417	49	5.22585	22605	22625	22645	22666	22686
50	0.07397	07377	07357	07337	07317	07297	50	5.22706	22726	22746	22766	22786	22806
51	0.07277	07257	07237	07217	07197	07178	51	5.22826	22846	22866	22886	22906	22925
52	0.07158	07138	07119	07099	07079	07060	52	5.22945	22965	22984	23004	23024	23043
53	0.07040	07021	07001	06982	06962	06943	53	5.23063	23082	23102	23121	23141	23160
54	0.06924	06904	06885	06866	06846	06827	54	5.23180	23199	23218	23237	23257	23276
55	0.06808	06789	06770	06751	06731	06712	55	5.23295	23314	23333	23352	23372	23391
56	0.06693	06674	06656	06637	06618	06599	56	5.23410	23429	23447	23466	23485	23504
57	0.06580	06561	06543	06524	06505	06487	57	5.23523	23542	23560	23579	23598	23616
58	0.06468	06449	06431	06412	06394	06375	58	5.23635	23654	23672	23691	23709	23728
59	0.06357	[illegible]	[illegible]	06302	[illegible]	[illegible]	59	5.23746	23765	23783	23801	23820	23838

TABLE XXIV.

OF NATURAL SINES.

	25°		26°		27°		28°		29°		
M	N. sine	N. cos	N. sine	N. cos	N. sine	N. cos	N. sine	N. cos	N. sine.	N. cos.	
0	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	48481	87462	60
1	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	87448	59
2	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	48532	87434	58
3	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	47024	[illegible]	[illegible]	87420	57
4	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	87406	56
5	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	87391	55
6	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	47101	[illegible]	[illegible]	87377	54
7	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	47127	[illegible]	[illegible]	87363	53
8	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	47153	[illegible]	[illegible]	87349	52
9	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	47178	[illegible]	48710	87335	51
10	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	47204	[illegible]	48735	87321	50
11	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	48761	87306	49
12	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	47255	[illegible]	48786	87292	48
13	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	48811	87278	47
14	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	48837	87264	46
15	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	48862	87250	45
16	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	48888	87235	44
17	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	47383	88062	48913	87221	43
18	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	47409	[illegible]	48938	87207	42
19	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	48964	87193	41
20	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	48989	87178	40
21	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	49014	87164	39
22	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	47511	[illegible]	49040	87150	38
23	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	49065	87136	37
24	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	49090	87121	36
25	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	87951	49116	87107	35
26	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	49141	87093	34
27	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	87923	49166	87079	33
28	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	49192	87064	32
29	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	87896	49217	87050	31
30	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	87882	49242	87036	30
31	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	47741	87868	49268	87021	29
32	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	87854	49293	87007	28
33	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	87840	49318	86993	27
34	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	47818	87826	49344	86978	26
35	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	47844	87812	49369	86964	25
36	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	47869	87798	49394	86949	24
37	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	49419	[illegible]	23
38	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	87770	[illegible]	86921	22
39	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	21
40	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	20
41	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	19
42	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	18
43	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	17
44	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	16
45	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	15
46	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	14
47	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	13
48	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	12
49	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	11
50	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	10
51	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
52	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
53	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
54	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
55	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	5
56	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	4
57	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	3
58	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	2
59	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	1
60	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	0
	N. cos.	N. sine.	N. cos.	N. sine.	N. cos.	N. sine.	N. cos.	N. sine.	N. cos.	N. sine.	M
	64°		[illegible]		[illegible]		61°		[illegible]		

TABLE XXV.

Of Logarithmic Sines, Tangents, and Secants to every Point and Quarter Point of the Compass.

Points.	Sine.	Co. sine.	Tangent.	Co. tang.	Secant.	Co. secant.	
0	Inf. neg.	10.00000	Inf. neg.	Infinite.	10.00000	Infinite.	8
0 ¼	8.69080	9.99948	8.69132	11.30868	10.00052	11.30920	7 ¾
0 ½	8.99130	9.99790	8.99340	11.00660	10.00210	11.00870	7 ½
0 ¾	9.16652	9.99527	9.17125	10.82875	10.00473	10.83348	7 ¼
1	9.29024	9.99157	9.29866	10.70134	10.00843	10.70976	7
1 ¼	9.38557	9.98679	9.39879	10.60121	10.01321	10.61443	6 ¾
1 ½	9.46282	9.98088	9.48194	10.51806	10.01912	10.53718	6 ½
1 ¾	9.52749	9.97384	9.55365	10.44635	10.02616	10.47251	6 ¼
2	9.58284	9.96562	9.61722	10.38278	10.03438	10.41716	6
2 ¼	9.63099	9.95616	9.67483	10.32517	10.04384	10.36901	5 ¾
2 ½	9.67339	9.94543	9.72796	10.27204	10.05457	10.32661	5 ½
2 ¾	9.71105	9.93335	9.77770	10.22230	10.06665	10.28895	5 ¼
3	9.74474	9.91985	9.82489	10.17511	10.08015	10.25526	5
3 ¼	9.77503	9.90483	9.87020	10.12980	10.09517	10.22497	4 ¾
3 ½	9.80236	9.88819	9.91417	10.08583	10.11181	10.19764	4 ½
3 ¾	9.82708	9.86979	9.95729	10.04271	10.13021	10.17292	4 ¼
4	9.84949	9.84949	10.00000	10.00000	10.15051	10.15051	4
	Co. sine.	Sine.	Co. tang.	Tangent.	Co. secant.	Secant.	Points.

TABLE XXVI.

LOGARITHMS OF NUMBERS.

No. 1——100. Log. 0.00000——2.00000.

N.	Log.	N.	Log.	N.	Log.	N.	Log.	N.	Log.
1	0.00000	21	1.32222	41	1.61278	61	1.78533	81	1.90849
2	0.30103	22	1.34242	42	1.62325	62	1.79239	82	1.91381
3	0.47712	23	1.36173	43	1.63347	63	1.79934	83	1.91908
4	0.60206	24	1.38021	44	1.64345	64	1.80618	84	1.92428
5	0.69897	25	1.39794	45	1.65321	65	1.81291	85	1.92942
6	0.77815	26	1.41497	46	1.66276	66	1.81954	86	1.93450
7	0.84510	27	1.43136	47	1.67210	67	1.82607	87	1.93952
8	0.90309	28	1.44716	48	1.68124	68	1.83251	88	1.94448
9	0.95424	29	1.46240	49	1.69020	69	1.83885	89	1.94939
10	1.00000	30	1.47712	50	1.69897	70	1.84510	90	1.95424
11	1.04139	31	1.49136	51	1.70757	71	1.85126	91	1.95904
12	1.07918	32	1.50515	52	1.71600	72	1.85733	92	1.96379
13	1.11394	33	1.51851	53	1.72428	73	1.86332	93	1.96848
14	1.14613	34	1.53148	54	1.73239	74	1.86923	94	1.97313
15	1.17609	35	1.54407	55	1.74036	75	1.87506	95	1.97772
16	1.20412	36	1.55630	56	1.74819	76	1.88081	96	1.98227
17	1.23045	37	1.56820	57	1.75587	77	1.88649	97	1.98677
18	1.25527	38	1.57978	58	1.76343	78	1.89209	98	1.99123
19	1.27875	39	1.59106	59	1.77085	79	1.89763	99	1.99564
20	1.30103	40	1.60206	60	1.77815	80	1.90309	100	2.00000

TABLE XXVI.

LOGARITHMS OF NUMBERS.

No. 100——1600. Log. 00000——20412.

No.	0	1	2	3	4	5	6	7	8	9
100	00000	00043	00087	00130	00173	00217	00260	00303	00346	00389
101	00432	00475	00518	00561	00604	00647	00689	00732	00775	00817
102	00860	00903	00945	00988	01030	01072	01115	01157	01199	01242
103	01284	01326	01368	01410	01452	01494	01536	01578	01620	01662
104	01703	01745	01787	01828	01870	01912	01953	01995	02036	02078
105	02119	02160	02202	02243	02284	02325	02366	02407	02449	02490
106	02531	02572	02612	02653	02694	02735	02776	02816	02857	02898
107	02938	02979	03019	03060	03100	03141	03181	03222	03262	03302
108	03342	03383	03423	03463	03503	03543	03583	03623	03663	03703
109	03743	03782	03822	03862	03902	03941	03981	04021	04060	04100
110	04139	04179	04218	04258	04297	04336	04376	04415	04454	04493
111	04532	04571	04610	04650	04689	04727	04766	04805	04844	04883
112	04922	04961	04999	05038	05077	05115	05154	05192	05231	05269
113	05308	05346	05385	05423	05461	05500	05538	05576	05614	05652
114	05690	05729	05767	05805	05843	05881	05918	05956	05994	06032
115	06070	06108	06145	06183	06221	06258	06296	06333	06371	06408
116	06446	06483	06521	06558	06595	06633	06670	06707	06744	06781
117	06819	06856	06893	06930	06967	07004	07041	07078	07115	07151
118	07188	07225	07262	07298	07335	07372	07408	07445	07482	07518
119	07555	07591	07628	07664	07700	07737	07773	07809	07846	07882
120	07918	07954	07990	08027	08063	08099	08135	08171	08207	08243
121	08279	08314	08350	08386	08422	08458	08493	08529	08565	08600
122	08636	08672	08707	08743	08778	08814	08849	08884	08920	08955
123	08991	09026	09061	09096	09132	09167	09202	09237	09272	09307
124	09342	09377	09412	09447	09482	09517	09552	09587	09621	09656
125	09691	09726	09760	09795	09830	09864	09899	09934	09968	10003
126	10037	10072	10106	10140	10175	10209	10243	10278	10312	10346
127	10380	10415	10449	10483	10517	10551	10585	10619	10653	10687
128	10721	10755	10789	10823	10857	10890	10924	10958	10992	11025
129	11059	11093	11126	11160	11193	11227	11261	11294	11327	11361
130	11394	11428	11461	11494	11528	11561	11594	11628	11661	11694
131	11727	11760	11793	11826	11860	11893	11926	11959	11992	12024
132	12057	12090	12123	12156	12189	12222	12254	12287	12320	12352
133	12385	12418	12450	12483	12516	12548	12581	12613	12646	12678
134	12710	12743	12775	12808	12840	12872	12905	12937	12969	13001
135	13033	13066	13098	13130	13162	13194	13226	13258	13290	13322
136	13354	13386	13418	13450	13481	13513	13545	13577	13609	13640
137	13672	13704	13735	13767	13799	13830	13862	13893	13925	13956
138	13988	14019	14051	14082	14114	14145	14176	14208	14239	14270
139	14301	14333	14364	14395	14426	14457	14489	14520	14551	14582
140	14613	14644	14675	14706	14737	14768	14799	14829	14860	14891
141	14922	14953	14983	15014	15045	15076	15106	15137	15168	15198
142	15229	15259	15290	15320	15351	15381	15412	15442	15473	15503
143	15534	15564	15594	15625	15655	15685	15715	15746	15776	15806
144	15836	15866	15897	15927	15957	15987	16017	16047	16077	16107
145	16137	16167	16197	16227	16256	16286	16316	16346	16376	16406
146	16435	16465	16495	16524	16554	16584	16613	16643	16673	16702
147	16732	16761	16791	16820	16850	16879	16909	16938	16967	16997
148	17026	17056	17085	17114	17143	17173	17202	17231	17260	17289
149	17319	17348	17377	17406	17435	17464	17493	17522	17551	17580
150	17609	17638	17667	17696	17725	17754	17782	17811	17840	17869
151	17898	17926	17955	17984	18013	18041	18070	18099	18127	18156
152	18184	18213	18241	18270	18298	18327	18355	18384	18412	18441
153	18469	18498	18526	18554	18583	18611	18639	18667	18696	18724
154	18752	18780	18808	18837	18865	18893	18921	18949	18977	19005
155	19033	19061	19089	19117	19145	19173	19201	19229	19257	19285
156	19312	19340	19368	19396	19424	19451	19479	19507	19535	19562
157	19590	19618	19645	19673	19700	19728	19756	19783	19811	19838
158	19866	19893	19921	19948	19976	20003	20030	20058	20085	20112
159	20140	20167	20194	20222	20249	20276	20303	20330	20358	20385
No.	0	1	2	3	4	5	6	7	8	9

TABLE XXVI.

LOGARITHMS OF NUMBERS.

No. 2200———2800. Log. 34242———44716.

No.	0	1	2	3	4	5	6	7	8	9
220	34242	34262	34282	34301	34321	34341	34361	34380	34400	34420
221	34439	34459	34479	34498	34518	34537	34557	34577	34596	34616
222	34635	34655	34674	34694	34713	34733	34753	34772	34792	34811
223	34830	34850	34869	34889	34908	34928	34947	34967	34986	35005
224	35025	35044	35064	35083	35102	35122	35141	35160	35180	35199
225	35218	35238	35257	35276	35295	35315	35334	35353	35372	35392
226	35411	35430	35449	35468	35488	35507	35526	35545	35564	35583
227	35603	35622	35641	35660	35679	35698	35717	35736	35755	35774
228	35793	35813	35832	35851	35870	35889	35908	35927	35946	35965
229	35984	36003	36021	36040	36059	36078	36097	36116	36135	36154
230	36173	36192	36211	36229	36248	36267	362[illegible]	36305	36324	36342
231	36361	36380	36399	36418	36436	36455	36474	36493	36511	36530
232	36549	36568	36586	36605	36624	36642	36661	36680	36698	36717
233	36736	36754	36773	36791	36810	36829	36847	36866	36884	36903
234	36922	36940	36959	36977	36996	37014	37033	37051	37070	37088
235	37107	37125	37144	37162	37181	37199	37218	37236	37254	37273
236	37291	37310	37328	37346	37365	37383	37401	37420	37438	37457
237	37475	37493	37511	37530	37548	37566	37585	37603	37621	37639
238	37658	37676	37694	37712	37731	37749	37767	37785	37803	37822
239	37840	37858	37876	37894	37912	37931	37949	37967	37985	38003
240	38021	38039	38057	38075	38093	38112	38130	38148	38166	38184
241	38202	38220	38238	38256	38274	38292	38310	38328	38346	38364
242	38382	38399	38417	38435	38453	38471	38489	38507	38525	38543
243	38561	38578	38596	38614	38632	38650	38668	38686	38703	38721
244	38739	38757	38775	38792	38810	38828	38846	38863	38881	38899
245	38917	38934	38952	38970	38987	39005	39023	39041	39058	39076
246	39094	39111	39129	39146	39164	39182	39199	39217	39235	39252
247	39270	39287	39305	39322	39340	39358	39375	39393	39410	39428
248	39445	39463	39480	39498	39515	39533	39550	39568	39585	39602
249	39620	39637	39655	39672	39690	39707	39724	39742	39759	39777
250	39794	39811	39829	39846	39863	39881	39898	39915	39933	39950
251	39967	39985	40002	40019	40037	40054	40071	40088	40106	40123
252	40140	40157	40175	40192	40209	40226	40243	40261	40278	40295
253	40312	40329	40346	40364	40381	40398	40415	40432	40449	40466
254	40483	40500	40518	40535	40552	40569	40586	40603	40620	40637
255	40654	40671	40688	40705	40722	40739	40756	40773	40790	40807
256	40824	40841	40858	40875	40892	40909	40926	40943	40960	40976
257	40993	41010	41027	41044	41061	41078	41095	41111	41128	41145
258	41162	41179	41196	41212	41229	41246	41263	41280	41296	41313
259	41330	41347	41363	41380	41397	41414	41430	41447	41464	41481
260	41497	41514	41531	41547	41564	41581	41597	41614	41631	41647
261	41664	41681	41697	41714	41731	41747	41764	41780	41797	41814
262	41830	41847	41863	41880	41896	41913	41929	41946	41963	41979
263	41996	42012	42029	42045	42062	42078	42095	42111	42127	42144
264	42160	42177	42193	42210	42226	42243	42259	42275	42292	42308
265	42325	42341	42357	42374	42390	42406	42423	42439	42455	42472
266	42488	42504	42521	42537	42553	42570	42586	42602	42619	42635
267	42651	42667	42684	42700	42716	42732	42749	42765	42781	42797
268	42813	42830	42846	42862	42878	42894	42911	42927	42943	42959
269	42975	42991	43008	43024	43040	43056	43072	43088	43104	43120
270	43136	43152	43169	43185	43201	43217	43233	43249	43265	43281
271	43297	43313	43329	43345	43361	43377	43393	43409	43425	43441
272	43457	43473	43489	43505	43521	43537	43553	43569	43584	43600
273	43616	43632	43648	43664	43680	43696	43712	43727	43743	43759
274	43775	43791	43807	43823	43838	43854	43870	43886	43902	43917
275	43933	43949	43965	43981	43996	44012	44028	44044	44059	44075
276	44091	44107	44122	44138	44154	44170	44185	44201	44217	44232
277	44248	44264	44279	44295	44311	44326	44342	44358	44373	44389
278	44404	44420	44436	44451	44467	44483	44498	44514	44529	44545
279	44560	44576	44592	44607	44623	44638	44654	44669	44685	44700
No.	0	1	2	3	4	5	6	7	8	9

TABLE XXVI.

LOGARITHMS OF NUMBERS.

No. 2800———3400. Log. 44716———53148.

No.	0	1	2	3	4	5	6	7	8	9
280	44716	44731	44747	44762	44778	44793	44809	44824	44840	44855
281	44871	44886	44902	44917	44932	44948	44963	44979	44994	45010
282	45025	45040	45056	45071	45086	45102	45117	45133	45148	45163
283	45179	45194	45209	45225	45240	45255	45271	45286	45301	45317
284	45332	45347	45362	45378	45393	45408	45423	45439	45454	45469
285	45484	45500	45515	45530	45545	45561	45576	45591	45606	45621
286	45637	45652	45667	45682	45697	45712	45728	45743	45758	45773
287	45788	45803	45818	45834	45849	45864	45879	45894	45909	45924
288	45939	45954	45969	45984	46000	46015	46030	46045	46060	46075
289	46090	46105	46120	46135	46150	46165	46180	46195	46210	46225
290	46240	46255	46270	46285	46300	46315	46330	46345	46359	46374
291	46389	46404	46419	46434	46449	46464	46479	46494	46509	46523
292	46538	46553	46568	46583	46598	46613	46627	46642	46657	46672
293	46687	46702	46716	46731	46746	46761	46776	46790	46805	46820
294	46835	46850	46864	46879	46894	46909	46923	46938	46953	46967
295	46982	46997	47012	47026	47041	47056	47070	47085	47100	47114
296	47129	47144	47159	47173	47188	47202	47217	47232	47246	47261
297	47276	47290	47305	47319	47334	47349	47363	47378	47392	47407
298	47422	47436	47451	47465	47480	47494	47509	47524	47538	47553
299	47567	47582	47596	47611	47625	47640	47654	47669	47683	47698
300	47712	47727	47741	47756	47770	47784	47799	47813	47828	47842
301	47857	47871	47885	47900	47914	47929	47943	47958	47972	47986
302	48001	48015	48029	48044	48058	48073	48087	48101	48116	48130
303	48144	48159	48173	48187	48202	48216	48230	48244	48259	48273
304	48287	48302	48316	48330	48344	48359	48373	48387	48401	48416
305	48430	48444	48458	48473	48487	48501	48515	48530	48544	48558
306	48572	48586	48601	48615	48629	48643	48657	48671	48686	48700
307	48714	48728	48742	48756	48770	48785	48799	48813	48827	48841
308	48855	48869	48883	48897	48911	48926	48940	48954	48968	48982
309	48996	49010	49024	49038	49052	49066	49080	49094	49108	49122
310	49136	49150	49164	49178	49192	49206	49220	49234	49248	49262
311	49276	49290	49304	49318	49332	49346	49360	49374	49388	49402
312	49415	49429	49443	49457	49471	49485	49499	49513	49527	49541
313	49554	49568	49582	49596	49610	49624	49638	49651	49665	49679
314	49693	49707	49721	49734	49748	49762	49776	49790	49803	49817
315	49831	49845	49859	49872	49886	49900	49914	49927	49941	49955
316	49969	49982	49996	50010	50024	50037	50051	50065	50079	50092
317	50106	50120	50133	50147	50161	50174	50188	50202	50215	50229
318	50243	50256	50270	50284	50297	50311	50325	50338	50352	50365
319	50379	50393	50406	50420	50433	50447	50461	50474	50488	50501
320	50515	50529	50542	50556	50569	50583	50596	50610	50623	50637
321	50651	50664	50678	50691	50705	50718	50732	50745	50759	50772
322	50786	50799	50813	50826	50840	50853	50866	50880	50893	50907
323	50920	50934	50947	50961	50974	50987	51001	51014	51028	51041
324	51055	51068	51081	51095	51108	51121	51135	51148	51162	51175
325	51188	51202	51215	51228	51242	51255	51268	51282	51295	51308
326	51322	51335	51348	51362	51375	51388	51402	51415	51428	51441
327	51455	51468	51481	51495	51508	51521	51534	51548	51561	51574
328	51587	51601	51614	51627	51640	51654	51667	51680	51693	51706
329	51720	51733	51746	51759	51772	51786	51799	51812	51825	51838
330	51851	51865	51878	51891	51904	51917	51930	51943	51957	51970
331	51983	51996	52009	52022	52035	52048	52061	52075	52088	52101
332	52114	52127	52140	52153	52166	52179	52192	52205	52218	52231
333	52244	52257	52270	52284	52297	52310	52323	52336	52349	52362
334	52375	52388	52401	52414	52427	52440	52453	52466	52479	52492
335	52504	52517	52530	52543	52556	52569	52582	52595	52608	52621
336	52634	52647	52660	52673	52686	52699	52711	52724	52737	52750
337	52763	52776	52789	52802	52815	52827	52840	52853	52866	52879
338	52892	52905	52917	52930	52943	52956	52969	52982	52994	53007
339	53020	53033	53046	53058	53071	53084	53097	53110	53122	53135
No.	0	1	2	3	4	5	6	7	8	9

LOGARITHMS OF NUMBERS.

No. 3400——4000. Log. 53148——60206.

No.	0	1	2	3	4	5	6	7	8	9
340	5314	53161	53173	53186	53199	53212	53224	53237	53250	53263
341	53275	53288	53301	53314	53326	53339	53352	53364	53377	53390
342	53403	53415	53428	53441	53453	53466	53479	53491	53504	53517
343	53529	53542	53555	53567	53580	53593	53605	53618	53631	53643
344	53656	53668	536[illegible]	53694	53706	53719	53732	53744	53757	53769
345	53782	53794	53807	53820	53832	53845	53857	53870	53882	53895
346	53908	53920	53933	53945	53958	53970	53983	53995	54008	54020
347	54033	54045	54058	54070	54083	54095	54108	54120	54133	54145
348	54158	54170	54183	54195	54208	54220	54233	54245	54258	54270
349	54283	54295	54307	54320	54332	54345	54357	54370	54382	54394
350	54407	54419	54432	54444	54456	54469	54481	54494	54506	54518
351	54531	54543	54555	54568	54580	54593	54605	54617	54630	54642
352	54654	54667	54679	54691	54704	54716	54728	54741	54753	54765
353	54777	54790	54802	54814	54827	54839	54851	54864	54876	54888
354	54900	54913	54925	54937	54949	54962	54974	54986	54998	55011
355	55023	55035	55047	55060	55072	55084	55096	55108	55121	55133
356	55145	55157	55169	55182	55194	55206	55218	55230	55242	55255
357	55267	55279	55291	55303	55315	55328	55340	55352	55364	55376
358	55388	55400	55413	55425	55437	55449	55461	55473	55485	55497
359	55509	55522	55534	55546	55558	55570	55582	55594	55606	55618
360	55630	55642	55654	55666	55678	55691	55703	55715	55727	55739
361	55751	55763	55775	55787	55799	55811	55823	55835	55847	55859
362	55871	55883	55895	55907	55919	55931	55943	55955	55967	55979
363	55991	56003	56015	56027	56038	56050	56062	56074	56086	56098
364	56110	56122	56134	56146	56158	56170	56182	56194	56205	56217
365	56229	56241	56253	56265	56277	56289	56301	56312	56324	56336
366	56348	56360	56372	56384	56396	56407	56419	56431	56443	56455
367	56467	56478	56490	56502	56514	56526	56538	56549	56561	56573
368	56585	56597	56608	56620	56632	56644	56656	56667	56679	56691
369	56703	56714	56726	56738	56750	56761	56773	56785	56797	56808
370	56820	56832	56844	56855	56867	56879	56891	56902	56914	56926
371	56937	56949	56961	56972	56984	56996	57008	57019	57031	57043
372	57054	57066	57078	57089	57101	57113	57124	57136	57148	57159
373	57171	57183	57194	57206	57217	57229	57241	57252	57264	57276
374	57287	57299	57310	57322	57334	57345	57357	57368	57380	57392
375	57403	57415	57426	57438	57449	57461	57473	57484	57496	57507
376	57519	57530	57542	57553	57565	57576	57588	57600	57611	57623
377	57634	57646	57657	57669	57680	57692	57703	57715	57726	57738
378	57749	57761	57772	57784	57795	57807	57818	57830	57841	57852
379	57864	57875	57887	57898	57910	57921	57933	57944	57955	57967
380	57978	57990	58001	58013	58024	58035	58047	58058	58070	58081
381	58092	58104	58115	58127	58138	58149	58161	58172	58184	58195
382	58206	58218	58229	58240	58252	58263	58274	58286	58297	58309
383	58320	58331	58343	58354	58365	58377	58388	58399	58410	58422
384	58433	58444	58456	58467	58478	58490	58501	58512	58524	58535
385	58546	58557	58569	58580	58591	58602	58614	58625	58636	58647
386	58659	58670	58681	58692	58704	58715	58726	58737	58749	58760
387	58771	58782	58794	58805	58816	58827	58838	58850	58861	58872
388	58883	58894	58906	58917	58928	58939	58950	58961	58973	58984
389	58995	59006	59017	59028	59040	59051	59062	59073	59084	59095
390	59106	59118	59129	59140	59151	59162	59173	59184	59195	59207
391	59218	59229	59240	59251	59262	59273	59284	59295	59306	59318
392	59329	59340	59351	59362	59373	59384	59395	59406	59417	59428
393	59439	59450	59461	59472	59483	59494	59506	59517	59528	59539
394	59550	59561	59572	59583	59594	59605	59616	59627	59638	59649
395	59660	59671	59682	59693	59704	59715	59726	59737	59748	59759
396	59770	59780	59791	59802	59813	59824	59835	59846	59857	59868
397	59879	59890	59901	59912	59923	59934	59945	59956	59966	59977
398	59988	59999	60010	60021	60032	60043	60054	60065	60076	60086
399	60097	60108	60119	60130	60141	60152	60163	60173	60184	60195
No.	0	1	2	3	4	5	6	7	8	9

LOGARITHMS OF NUMBERS.

No. 5200———5800. Log. 71600———76343.

No.	0	1	2	3	4	5	6	7	8	9
520	71600	71609	71617	71625	71634	71642	71650	71659	71667	71675
521	71684	71692	71700	71709	71717	71725	71734	71742	71750	71759
522	71767	71775	71784	71792	71800	71809	71817	71825	71834	71842
523	71850	71858	71867	71875	71883	71892	71900	71908	71917	71925
524	71933	71941	71950	71958	71966	71975	71983	71991	71999	72008
525	72016	72024	72032	72041	72049	72057	72066	72074	72082	72090
526	72099	72107	72115	72123	72132	72140	72148	72156	72165	72173
527	72181	72189	72198	72206	72214	72222	72230	72239	72247	72255
528	72263	72272	72280	72288	72296	72304	72313	72321	72329	72337
529	72346	72354	72362	72370	72378	72387	72395	72403	72411	72419
530	72428	72436	72444	72452	72460	72469	72477	72485	72493	72501
531	72509	72518	72526	72534	72542	72550	72558	72567	72575	72583
532	72591	72599	72607	72616	72624	72632	72640	72648	72656	72665
533	72673	72681	72689	72697	72705	72713	72722	72730	72738	72746
534	72754	72762	72770	72779	72787	72795	72803	72811	72819	72827
535	72835	72843	72852	72860	72868	72876	72884	72892	72900	72908
536	72916	72925	72933	72941	72949	72957	72965	72973	72981	72989
537	72997	73006	73014	73022	73030	73038	73046	73054	73062	73070
538	73078	73086	73094	73102	73111	73119	73127	73135	73143	73151
539	73159	73167	73175	73183	73191	73199	73207	73215	73223	73231
540	73239	73247	73255	73263	73272	73280	73288	73296	73304	73312
541	73320	73328	73336	73344	73352	73360	73368	73376	73384	73392
542	73400	73408	73416	73424	73432	73440	73448	73456	73464	73472
543	73480	73488	73496	73504	73512	73520	73528	73536	73544	73552
544	73560	73568	73576	73584	73592	73600	73608	73616	73624	73632
545	73640	73648	73656	73664	73672	73679	73687	73695	73703	73711
546	73719	73727	73735	73743	73751	73759	73767	73775	73783	73791
547	73799	73807	73815	73823	73830	73838	73846	73854	73862	73870
548	73878	73886	73894	73902	73910	73918	73926	73933	73941	73949
549	73957	73965	73973	73981	73989	73997	74005	74013	74020	74028
550	74036	74044	74052	74060	74068	74076	74084	74092	74099	74107
551	74115	74123	74131	74139	74147	74155	74162	74170	74178	74186
552	74194	74202	74210	74218	74225	74233	74241	74249	74257	74265
553	74273	74280	74288	74296	74304	74312	74320	74327	74335	74343
554	74351	74359	74367	74374	74382	74390	74398	74406	74414	74421
555	74429	74437	74445	74453	74461	74468	74476	74484	74492	74500
556	74507	74515	74523	74531	74539	74547	74554	74562	74570	74578
557	74586	74593	74601	74609	74617	74624	74632	74640	74648	74656
558	74663	74671	74679	74687	74695	74702	74710	74718	74726	74733
559	74741	74749	74757	74764	74772	74780	74788	74796	74803	74811
560	74819	74827	74834	74842	74850	74858	74865	74873	74881	74889
561	74896	74904	74912	74920	74927	74935	74943	74950	74958	74966
562	74974	74981	74989	74997	75005	75012	75020	75028	75035	75043
563	75051	75059	75066	75074	75082	75089	75097	75105	75113	75120
564	75128	75136	75143	75151	75159	75166	75174	75182	75189	75197
565	75205	75213	75220	75228	75236	75243	75251	75259	75266	75274
566	75282	75289	75297	75305	75312	75320	75328	75335	75343	75351
567	75358	75366	75374	75381	75389	75397	75404	75412	75420	75427
568	75435	75442	75450	75458	75465	75473	75481	75488	75496	75504
569	75511	75519	75526	75534	75542	75549	75557	75565	75572	75580
570	75587	75595	75603	75610	75618	75626	75633	75641	75648	75656
571	75664	75671	75679	75686	75694	75702	75709	75717	75724	75732
572	75740	75747	75755	75762	75770	75778	75785	75793	75800	75808
573	75815	75823	75831	75838	75846	75853	75861	75868	75876	75884
574	75891	75899	75906	75914	75921	75929	75937	75944	75952	75959
575	75967	75974	75982	75989	75997	76005	76012	76020	76027	76035
576	76042	76050	76057	76065	76072	76080	76087	76095	76103	76110
577	76118	76125	76133	76140	76148	76155	76163	76170	76178	76185
578	76193	76200	76208	76215	76223	76230	76238	76245	76253	76260
579	76268	76275	76283	76290	76298	76305	76313	76320	76328	76335
No.	0	1	2	3	4	5	6	7	8	9

LOGARITHMS OF NUMBERS.

No. 7000——7600. Log. 84510——88081.

No.	0	1	2	3	4	5	6	7	8	9
700	84510	84516	84522	84528	84535	84541	84547	84553	84559	84566
701	84572	84578	84584	84590	84597	84603	84609	84615	84621	84628
702	84634	84640	84646	84652	84658	84665	84671	84677	84683	84689
703	84696	84702	84708	84714	84720	84726	84733	84739	84745	84751
704	84757	84763	84770	84776	84782	84788	84794	84800	84807	84813
705	84819	84825	84831	84837	84844	84850	84856	84862	84868	84874
706	84880	84887	84893	84899	84905	84911	84917	84924	84930	84936
707	84942	84948	84954	84960	84967	84973	84979	84985	84991	84997
708	85003	85009	85016	85022	85028	85034	85040	85046	85052	85058
709	85065	85071	85077	85083	85089	85095	85101	85107	85114	85120
710	85126	85132	85138	85144	85150	85156	85163	85169	85175	85181
711	85187	85193	85199	85205	85211	85217	85224	85230	85236	85242
712	85248	85254	85260	85266	85272	85278	85285	85291	85297	85303
713	85309	85315	85321	85327	85333	85339	85345	85352	85358	85364
714	85370	85376	85382	85388	85394	85400	85406	85412	85418	85425
715	85431	85437	85443	85449	85455	85461	85467	85473	85479	85485
716	85491	85497	85503	85509	85516	85522	85528	85534	85540	85546
717	85552	85558	85564	85570	85576	85582	85588	85594	85600	85606
718	85612	85618	85625	85631	85637	85643	85649	85655	85661	85667
719	85673	85679	85685	85691	85697	85703	85709	85715	85721	85727
720	85733	85739	85745	85751	85757	85763	85769	85775	85781	85788
721	85794	85800	85806	85812	85818	85824	85830	85836	85842	85848
722	85854	85860	85866	85872	85878	85884	85890	85896	85902	85908
723	85914	85920	85926	85932	85938	85944	85950	85956	85962	85968
724	85974	85980	85986	85992	85998	86004	86010	86016	86022	86028
725	86034	86040	86046	86052	86058	86064	86070	86076	86082	86088
726	86094	86100	86106	86112	86118	86124	86130	86136	86141	86147
727	86153	86159	86165	86171	86177	86183	86189	86195	86201	86207
728	86213	86219	86225	86231	86237	86243	86249	86255	86261	86267
729	86273	86279	86285	86291	86297	86303	86308	86314	86320	86326
730	86332	86338	86344	86350	86356	86362	86368	86374	86380	86386
731	86392	86398	86404	86410	86415	86421	86427	86433	86439	86445
732	86451	86457	86463	86469	86475	86481	86487	86493	86499	86504
733	86510	86516	86522	86528	86534	86540	86546	86552	86558	86564
734	86570	86576	86581	86587	86593	86599	86605	86611	86617	86623
735	86629	86635	86641	86646	86652	86658	86664	86670	86676	86682
736	86688	86694	86700	86705	86711	86717	86723	86729	86735	86741
737	86747	86753	86759	86764	86770	86776	86782	86788	86794	86800
738	86806	86812	86817	86823	86829	86835	86841	86847	86853	86859
739	86864	86870	86876	86882	86888	86894	86900	86906	86911	86917
740	86923	86929	86935	86941	86947	86953	86958	86964	86970	86976
741	86982	86988	86994	86999	87005	87011	87017	87023	87029	87035
742	87040	87046	87052	87058	87064	87070	87075	87081	87087	87093
743	87099	87105	87111	87116	87122	87128	87134	87140	87146	87151
744	87157	87163	87169	87175	87181	87186	87192	87198	87204	87210
745	87216	87221	87227	87233	87239	87245	87251	87256	87262	87268
746	87274	87280	87286	87291	87297	87303	87309	87315	87320	87326
747	87332	87338	87344	87349	87355	87361	87367	87373	87379	87384
748	87390	87396	87402	87408	87413	87419	87425	87431	87437	87442
749	87448	87454	87460	87466	87471	87477	87483	87489	87495	87500
750	87506	87512	87518	87523	87529	87535	87541	87547	87552	87558
751	87564	87570	87576	87581	87587	87593	87599	87604	87610	87616
752	87622	87628	87633	87639	87645	87651	87656	87662	87668	87674
753	87679	87685	87691	87697	87703	87708	87714	87720	87726	87731
754	87737	87743	87749	87754	87760	87766	87772	87777	87783	87789
755	87795	87800	87806	87812	87818	87823	87829	87835	87841	87846
756	87852	87858	87864	87869	87875	87881	87887	87892	87898	87904
757	87910	87915	87921	87927	87933	87938	87944	87950	87955	87961
758	87967	87973	87978	87984	87990	87996	88001	88007	88013	88018
759	88024	88030	88036	88041	88047	88053	88058	88064	88070	88076
No.	0	1	2	3	4	5	6	7	8	9

Log. Sines, Tangents and Secants.

1 Deg. Degs. 178.

M.	Hour A.M.	Hour P.M.	Sine.	Co-sine.	Tangent.	Co-tang.	Secant.	Co-secant	M.
0	11 52 0	0 8 0	8.24186	9.99993	8.24192	11.75808	10.00007	11.75814	60
1	51 52	8 8	24903	99993	24910	75090	00007	75097	59
2	51 44	8 16	25609	99993	25616	74384	00007	74391	58
3	51 36	8 24	26304	99993	26312	73688	00007	73696	57
4	51 28	8 32	26988	99992	26996	73004	00008	73012	56
5	11 51 20	0 8 40	8.27661	9.99992	8.27669	11.72331	10.00008	11.72339	55
6	51 12	8 48	28324	99992	28332	71668	00008	71676	54
7	51 4	8 56	28977	99992	28986	71014	00008	71023	53
8	50 56	9 4	29621	99992	29629	70371	00008	70379	52
9	50 48	9 12	30255	99991	30263	69737	00009	69745	51
10	11 50 40	0 9 20	8.30879	9.99991	8.30888	11.69112	10.00009	11.69121	50
11	50 32	9 28	31495	99991	31505	68495	00009	68505	49
12	50 24	9 36	32103	99990	32112	67888	00010	67897	48
13	50 16	9 44	32702	99990	32711	67289	00010	67298	47
14	50 8	9 52	33292	99990	33302	66698	00010	66708	46
15	11 50 0	0 10 0	8.33875	9.99990	8.33886	11.66114	10.00010	11.66125	45
16	49 52	10 8	34450	99989	34461	65539	00011	65550	44
17	49 44	10 16	35018	99989	35029	64971	00011	64982	43
18	49 36	10 24	35578	99989	35590	64410	00011	64422	42
19	49 28	10 32	36131	99989	36143	63857	00011	63869	41
20	11 49 20	0 10 40	8.36678	9.99988	8.36689	11.63311	10.00012	11.63322	40
21	49 12	10 48	37217	99988	37229	62771	00012	62783	39
22	49 4	10 56	37750	99988	37762	62238	00012	62250	38
23	48 56	11 4	38276	99987	38289	61711	00013	61724	37
24	48 48	11 12	38796	99987	38809	61191	00013	61204	36
25	11 48 40	0 11 20	8.39310	9.99987	8.39323	11.60677	10.00013	11.60690	35
26	48 32	11 28	39818	99986	39832	60168	00014	60182	34
27	48 24	11 36	40320	99986	40334	59666	00014	59680	33
28	48 16	11 44	40816	99986	40830	59170	00014	59184	32
29	48 8	11 52	41307	99985	41321	58679	00015	58693	31
30	11 48 0	0 12 0	8.41792	9.99985	8.41807	11.58193	10.00015	11.58208	30
31	47 52	12 8	42272	99985	42287	57713	00015	57728	29
32	47 44	12 16	42746	99984	42762	57238	00016	57254	28
33	47 36	12 24	43216	99984	43232	56768	00016	56784	27
34	47 28	12 32	43680	99984	43696	56304	00016	56320	26
35	11 47 20	0 12 40	8.44139	9.99983	8.44156	11.55844	10.00017	11.55861	25
36	47 12	12 48	44594	99983	44611	55389	00017	55406	24
37	47 4	12 56	45044	99983	45061	54939	00017	54956	23
38	46 56	13 4	45489	99982	45507	54493	00018	54511	22
39	46 48	13 12	45930	99982	45948	54052	00018	54070	21
40	11 46 40	0 13 20	8.46366	9.99982	8.46385	11.53615	10.00018	11.53634	20
41	46 32	13 28	46799	99981	46817	53183	00019	53201	19
42	46 24	13 36	47226	99981	47245	52755	00019	52774	18
43	46 16	13 44	47650	99981	47669	52331	00019	52350	17
44	46 8	13 52	48069	99980	48089	51911	00020	51931	16
45	11 46 0	0 14 0	8.48485	9.99980	8.48505	11.51495	10.00020	11.51515	15
46	45 52	14 8	48896	99979	48917	51083	00021	51104	14
47	45 44	14 16	49304	99979	49325	50675	00021	50696	13
48	45 36	14 24	49708	99979	49729	50271	00021	50292	12
49	45 28	14 32	50108	99978	50130	49870	00022	49892	11
50	11 45 20	0 14 40	8.50504	9.99978	8.50527	11.49473	10.00022	11.49496	10
51	45 12	14 48	50897	99977	50920	49080	00023	49103	9
52	45 4	14 56	51287	99977	51310	48690	00023	48713	8
53	44 56	15 4	51673	99977	51696	48304	00023	48327	7
54	44 48	15 12	52055	99976	52079	47921	00024	47945	6
55	11 44 40	0 15 20	8.52434	9.99976	8.52459	11.47541	10.00024	11.47566	5
56	44 32	15 28	52810	99975	52835	47165	00025	47190	4
57	44 24	15 36	53183	99975	53208	46792	00025	46817	3
58	44 16	15 44	53552	99974	53578	46422	00026	46448	2
59	44 8	15 52	53919	99974	53945	46055	00026	46081	1
60	44 0	16 0	54282	99974	54308	45692	00026	45718	0
M.	Hour P.M.	Hour A.M.	Co-sine.	Sine.	Co-tang.	Tangent.	Co-secant	Secant	M.

91 Degs. Degs. 88.

Log. Sines, Tangents and Secants.

4 Degs. Degs. 175.

M	Hour A.M.	Hour P.M.	Sine.	Co-sine.	Tangent.	Co-tang.	Secant.	Co-secant.	M
0	11 28 0	0 32 0	8.84358	9.99894	8.84464	11.15536	10.00106	11.15642	60
1	27 52	32 8	84539	99893	84646	15354	00107	15461	59
2	27 44	32 16	84718	99892	85826	15174	00108	15282	58
3	27 36	32 24	84897	99891	85006	14994	00109	15103	57
4	27 28	32 32	85075	99891	85185	14815	00109	14925	56
5	11 27 20	0 32 40	8.85252	9.99890	8.85363	11.14637	10.00110	11.14748	55
6	27 12	32 48	85429	99889	85540	14460	00111	14571	54
7	27 4	32 56	85605	99888	85717	14283	00112	14395	53
8	26 56	33 4	85780	99887	85893	14107	00113	14220	52
9	26 48	33 12	85955	99886	86069	13931	00114	14045	51
10	11 26 40	0 33 20	8.86128	9.99885	8.86243	11.13757	10.00115	11.13872	50
11	26 32	33 28	86301	99884	86417	13583	00116	13699	49
12	26 24	33 36	86474	99883	86591	13409	00117	13526	48
13	26 16	33 44	86645	99882	86763	13237	00118	13355	47
14	26 8	33 52	86816	99881	86935	13065	00119	13184	46
15	11 26 0	0 34 0	8.86987	9.99880	8.87106	11.12894	10.00120	11.13013	45
16	25 52	34 8	87156	99879	87277	12723	00121	12844	44
17	25 44	34 16	87325	99879	87447	12553	00121	12675	43
18	25 36	34 24	87494	99878	87616	12384	00122	12506	42
19	25 28	34 32	87661	99877	87785	12215	00123	12339	41
20	11 25 20	0 34 40	8.87829	9.99876	8.87953	11.12047	10.00124	11.12171	40
21	25 12	34 48	87995	99875	88120	11880	00125	12005	39
22	25 4	34 56	88161	99874	88287	11713	00126	11839	38
23	24 56	35 4	88326	99873	88453	11547	00127	11674	37
24	24 48	35 12	88490	99872	88618	11382	00128	11510	36
25	11 24 40	0 35 20	8.88654	9.99871	8.88783	11.11217	10.00129	11.11346	35
26	24 32	35 28	88817	99870	88948	11052	00130	11183	34
27	24 24	35 36	88980	99869	89111	10889	00131	11020	33
28	24 16	35 44	89142	99868	89274	10726	00132	10858	32
29	24 8	35 52	89304	99867	89437	10563	00133	10696	31
30	11 24 0	0 36 0	8.89464	9.99866	8.89598	11.10402	10.00134	11.10536	30
31	23 52	36 8	89625	99865	89760	10240	00135	10375	29
32	23 44	36 16	89784	99864	89920	10080	00136	10216	28
33	23 36	36 24	89943	99863	90080	09920	00137	10057	27
34	23 28	36 32	90102	99862	90240	09760	00138	09898	26
35	11 23 20	0 36 40	8.90260	9.99861	8.90399	11.09601	10.00139	11.09740	25
36	23 12	36 48	90417	99860	90557	09443	00140	09583	24
37	23 4	36 56	90574	99859	90715	09285	00141	09426	23
38	22 56	37 4	90730	99858	90872	09128	00142	09270	22
39	22 48	37 12	90885	99857	91029	08971	00143	09115	21
40	11 22 40	0 37 20	8.91040	9.99856	8.91185	11.08815	10.00144	11.08960	20
41	22 32	37 28	91195	99855	91340	08660	00145	08805	19
42	22 24	37 36	91349	99854	91495	08505	00146	08651	18
43	22 16	37 44	91502	99853	91650	08350	00147	08498	17
44	22 8	37 52	91655	99852	91803	08197	00148	08345	16
45	11 22 0	0 38 0	8.91807	9.99851	8.91957	11.08043	10.00149	11.08193	15
46	21 52	38 8	91959	99850	92110	07890	00150	08041	14
47	21 44	38 16	92110	99848	92262	07738	00152	07890	13
48	21 36	38 24	92261	99847	92414	07586	00153	07739	12
49	21 28	38 32	92411	99846	92565	07435	00154	07589	11
50	11 21 20	0 38 40	8.92561	9.99845	8.92716	11.07284	10.00155	11.07439	10
51	21 12	38 48	92710	99844	92866	07134	00156	07290	9
52	21 4	38 56	92859	99843	93016	06984	00157	07141	8
53	20 56	39 4	93007	99842	93165	06835	00158	06993	7
54	20 48	39 12	93154	99841	93313	06687	00159	06846	6
55	11 20 40	0 39 20	8.93301	9.99840	8.93462	11.06538	10.00160	11.06699	5
56	20 32	39 28	93448	99839	93609	06391	00161	06552	4
57	20 24	39 36	93594	99838	93756	06244	00162	06406	3
58	20 16	39 44	93740	99837	93903	06097	00163	06260	2
59	20 8	39 52	93885	99836	94049	05951	00164	06115	1
60	20 0	40 0	94030	99834	94195	05805	00166	05970	0
M	Hour P.M.	Hour A.M.	Co-sine.	Sine.	Co-tang.	Tangent.	Co-secant	Secant.	M

94 Degs. Degs. 85.

TABLE XXVII.

Log. Sines, Tangents and Secants.

8 Degs. Degs. 171.

M	Hour A.M.	Hour P.M.	Sine.	Co-sine.	Tangent.	Co-tang.	Secant.	Co-secant	M
0	10 56 0	1 4 0	9.14356	9.99575	9.14780	10.85220	10.00425	10.85644	60
1	55 52	4 8	14445	99574	14872	85128	00426	85555	59
2	55 44	4 16	14535	99572	14963	85037	00428	85465	58
3	55 36	4 24	14624	99570	15054	84946	00430	85376	57
4	55 28	4 32	14714	99568	15145	84855	00432	85286	56
5	10 55 20	1 4 40	9.14803	9.99566	9.15236	10.84764	10.00434	10.85197	55
6	55 12	4 48	14891	99565	15327	84673	00435	85109	54
7	55 4	4 56	14980	99563	15417	84583	00437	85020	53
8	54 56	5 4	15069	99561	15508	84492	00439	84931	52
9	54 48	5 12	15157	99559	15598	84402	00441	84843	51
10	10 54 40	1 5 20	9.15245	9.99557	9.15688	10.84312	10.00443	10.84755	50
11	54 32	5 28	15333	99556	15777	84223	00444	84667	49
12	54 24	5 36	15421	99554	15867	84133	00446	84579	48
13	54 16	5 44	15508	99552	15956	84044	00448	84492	47
14	54 8	5 52	15596	99550	16046	83954	00450	84404	46
15	10 54 0	1 6 0	9.15683	9.99548	9.16135	10.83865	10.00452	10.84317	45
16	53 52	6 8	15770	99546	16224	83776	00454	84230	44
17	53 44	6 16	15857	99545	16312	83688	00455	84143	43
18	53 36	6 24	15944	99543	16401	83599	00457	84056	42
19	53 28	6 32	16030	99541	16489	83511	00459	83970	41
20	10 53 20	1 6 40	9.16116	9.99539	9.16577	10.83423	10.00461	10.83884	40
21	53 12	6 48	16203	99537	16665	83335	00463	83797	39
22	53 4	6 56	16289	99535	16753	83247	00465	83711	38
23	52 56	7 4	16374	99533	16841	83159	00467	83626	37
24	52 48	7 12	16460	99532	16928	83072	00468	83540	36
25	10 52 40	1 7 20	9.16545	9.99530	9.17016	10.82984	10.00470	10.83455	35
26	52 32	7 28	16631	99528	17103	82897	00472	83369	34
27	52 24	7 36	16716	99526	17190	82810	00474	83284	33
28	52 16	7 44	16801	99524	17277	82723	00476	83199	32
29	52 8	7 52	16886	99522	17363	82637	00478	83114	31
30	10 52 0	1 8 0	9.16970	9.99520	9.17450	10.82550	10.00480	10.83030	30
31	51 52	8 8	17055	99518	17536	82461	00482	82945	29
32	51 44	8 16	17139	99517	17622	82378	00483	82861	28
33	51 36	8 24	17223	99515	17708	82292	00485	82777	27
34	51 28	8 32	17307	99513	17794	82206	00487	82693	26
35	10 51 20	1 8 40	9.17391	9.99511	9.17880	10.82120	10.00489	10.82609	25
36	51 12	8 48	17474	99509	17965	82035	00491	82526	24
37	51 4	8 56	17558	99507	18051	81949	00493	82442	23
38	50 56	9 4	17641	99505	18136	81864	00495	82359	22
39	50 48	9 12	17724	99503	18221	81779	00497	82276	21
40	10 50 40	1 9 20	9.17807	9.99501	9.18306	10.81694	10.00499	10.82193	20
41	50 32	9 28	17890	99499	18391	81609	00501	82110	19
42	50 24	9 36	17973	99497	18475	81525	00503	82027	18
43	50 16	9 44	18055	99495	18560	81440	00505	81945	17
44	50 8	9 52	18137	99494	18644	81356	00506	81863	16
45	10 50 0	1 10 0	9.18220	9.99492	9.18728	10.81272	10.00508	10.81780	15
46	49 52	10 [illegible]	[illegible]	99490	18812	81188	00510	81698	14
47	49 44	10 16	18383	[illegible]	[illegible]	[illegible]	00512	81617	13
48	49 36	10 24	18465	99486	18979	81021	00514	[illegible]	12
49	49 28	10 32	18547	99484	19063	80937	00516	81453	11
50	10 49 20	1 10 40	9.18628	9.99482	9.19146	10.80854	10.00518	10.81372	10
51	49 12	10 48	18709	99480	19229	80771	00520	81291	9
52	49 4	10 56	18790	99478	19312	80688	00522	81210	8
53	48 56	11 4	18871	99476	19395	80605	00524	81129	7
54	48 48	11 12	18952	99474	19478	80522	00526	81048	6
55	10 48 40	1 11 20	9.19033	9.99472	9.19561	10.80439	10.00528	10.80967	5
56	48 32	11 28	19113	99470	19643	80357	00530	80887	4
57	48 24	11 36	19193	99468	19725	80275	00532	80807	3
58	48 16	11 44	19273	99466	19807	80193	00534	80727	2
59	48 8	11 52	19353	99464	19889	80111	00536	80647	1
60	48 0	12 0	19433	99462	19971	80029	00538	80567	0
M	Hour P.M.	Hour A.M.	Co-sine.	Sine.	Co-tang.	Tangent.	Co-secant.	Secant.	M

98 Degs. Degs. 81.

Log. Sines, Tangents and Secants.

11 Degs. Deg. 168.

M	Hour A.M.	Hour P.M.	Sine.	Co-sine.	Tangent.	Co-tang.	Secant.	Co-secant	M
0	10 32 0	1 28 0	9.28060	9.99195	9.28865	10.71135	10.00805	10.71940	60
1	31 52	28 8	28125	99192	28933	71067	00808	71875	59
2	31 44	28 16	28190	99190	29000	71000	00810	71810	58
3	31 36	28 24	28254	99187	29067	70933	00813	71746	57
4	31 28	28 32	28319	99185	29134	70866	00815	71681	56
5	10 31 20	1 28 40	9.28384	9.99182	9.29201	10.70799	10.00818	10.71616	55
6	31 12	28 48	28448	99180	29268	70732	00820	71552	54
7	31 4	28 56	28512	99177	29335	70665	00823	71488	53
8	30 56	29 4	28577	99175	29402	70598	00825	71423	52
9	30 48	29 12	28641	99172	29468	70532	00828	71359	51
10	10 30 40	1 29 20	9.28705	9.99170	9.29535	10.70465	10.00830	10.71295	50
11	30 32	29 28	28769	99167	29601	70399	00833	71231	49
12	30 24	29 36	28833	99165	29668	70332	00835	71167	48
13	30 16	29 44	28896	99162	29734	70266	00838	71104	47
14	30 8	29 52	28960	99160	29800	70200	00840	71040	46
15	10 30 0	1 30 0	9.29024	9.99157	9.29866	10.70134	10.00843	10.70976	45
16	29 52	30 8	29087	99155	29932	70068	00845	70913	44
17	29 44	30 16	29150	99152	29998	70002	00848	70850	43
18	29 36	30 24	29214	99150	30064	69936	00850	70786	42
19	29 28	30 32	29277	99147	30130	69870	00853	70723	41
20	10 29 20	1 30 40	9.29340	9.99145	9.30195	10.69805	10.00855	10.70660	40
21	29 12	30 48	29403	99142	30261	69739	00858	70597	39
22	29 4	30 56	29466	99140	30326	69674	00860	70534	38
23	28 56	31 4	29529	99137	30391	69609	00863	70471	37
24	28 48	31 12	29591	99135	30457	69543	00865	70409	36
25	10 28 40	1 31 20	9.29654	9.99132	9.30522	10.69478	10.00868	10.70346	35
26	28 32	31 28	29716	99130	30587	69413	00870	70284	34
27	28 24	31 36	29779	99127	30652	69348	00873	70221	33
28	28 16	31 44	29841	99124	30717	69283	00876	70159	32
29	28 8	31 52	29903	99122	30782	69218	00878	70097	31
30	10 28 0	1 32 0	9.29966	9.99119	9.30846	10.69154	10.00881	10.70034	30
31	27 52	32 8	30028	99117	30911	69089	00883	69972	29
32	27 44	32 16	30090	99114	30975	69025	00886	69910	28
33	27 36	32 24	30151	99112	31040	68960	00888	69849	27
34	27 28	32 32	30213	99109	31104	68896	00891	69787	26
35	10 27 20	1 32 40	9.30275	9.99106	9.31168	10.68832	10.00894	10.69725	25
36	27 12	32 48	30336	99104	31233	68767	00896	69664	24
37	27 4	32 56	30398	99101	31297	68703	00899	69602	23
38	26 56	33 4	30459	99099	31361	68639	00901	69541	22
39	26 48	33 12	30521	99096	31425	68575	00904	69479	21
40	10 26 40	1 33 20	9.30582	9.99093	9.31489	10.68511	10.00907	10.69418	20
41	26 32	33 28	30643	99091	31552	68448	00909	69357	19
42	26 24	33 36	30704	99088	31616	68384	00912	69296	18
43	26 16	33 44	30765	99086	31679	68321	00914	69235	17
44	26 8	33 52	30826	99083	31743	68257	00917	69174	16
45	10 26 0	1 34 0	9.30887	9.99080	9.31806	10.68194	10.00920	10.69113	15
46	25 52	34 8	30947	99078	31870	68130	00922	69053	14
47	25 44	34 16	31008	99075	31933	68067	00925	68992	13
48	25 36	34 24	31068	99072	31996	68004	00928	68932	12
49	25 28	34 32	31129	99070	32059	67941	00930	68871	11
50	10 25 20	1 34 40	9.31189	9.99067	9.32122	10.67878	10.00933	10.68811	10
51	25 12	34 48	31250	99064	32185	67815	00936	68750	9
52	25 4	34 56	31310	99062	32248	67752	00938	68690	8
53	24 56	35 4	31370	99059	32311	67689	00941	68630	7
54	24 48	35 12	31430	99056	32373	67627	00944	68570	6
55	10 24 40	1 35 20	9.31490	9.99054	9.32436	10.67564	10.00946	10.68510	5
56	24 32	35 28	31549	99051	32498	67502	00949	68451	4
57	24 24	35 36	31609	99048	32561	67439	00952	68391	3
58	24 16	35 44	31669	99046	32623	67377	00954	68331	2
59	24 8	35 52	31728	99043	32685	67315	00957	68272	1
60	24 0	36 0	31788	99040	32747	67253	00960	68212	0
M	Hour P.M.	Hour A.M.	Co-sine.	Sine.	Co-tang.	Tangent.	Co-secant	Secant.	M

101 Degs. Degs. 78.

Log. Sines, Tangents and Secants.

13 Degs. Degs. 166.

M	Hour A.M.	Hour P.M.	Sine.	Co-sine.	Tangent.	Co-tang.	Secant.	Co-secant	M
0	10 16 0	1 44 0	9.35209	9.98872	9.36336	10.63664	10.01128	10.64791	60
1	15 52	44 8	35263	98869	36394	63606	01131	64737	59
2	15 44	44 16	35318	98867	36452	63548	01133	64682	58
3	15 36	44 24	35373	98864	36509	63491	01136	64627	57
4	15 28	44 32	35427	98861	36566	63434	01139	64573	56
5	10 15 20	1 44 40	9.35481	9.98858	9.36624	10.63376	10.01142	10.64519	55
6	15 12	44 48	35536	98855	36681	63319	01145	64464	54
7	15 4	44 56	35590	98852	36738	63262	01148	64410	53
8	14 56	45 4	35644	98849	36795	63205	01151	64356	52
9	14 48	45 12	35698	98846	36852	63148	01154	64302	51
10	10 14 40	1 45 20	9.35752	9.98843	9.36909	10.63091	10.01157	10.64248	50
11	14 32	45 28	35806	98840	36966	63034	01160	64194	49
12	14 24	45 36	35860	98837	37023	62977	01163	64140	48
13	14 16	45 44	35914	98834	37080	62920	01166	64086	47
14	14 8	45 52	35968	98831	37137	62863	01169	64032	46
15	10 14 0	1 46 0	9.36022	9.98828	9.37193	10.62807	10.01172	10.63978	45
16	13 52	46 8	36075	98825	37250	62750	01175	63925	44
17	13 44	46 16	36129	98822	37306	62694	01178	63871	43
18	13 36	46 24	36182	98819	37363	62637	01181	63818	42
19	13 28	46 32	36236	98816	37419	62581	01184	63764	41
20	10 13 20	1 46 40	9.36289	9.98813	9.37476	10.62524	10.01187	10.63711	40
21	13 12	46 48	36342	98810	37532	62468	01190	63658	39
22	13 4	46 56	36395	98807	37588	62412	01193	63605	38
23	12 56	47 4	36449	98804	37644	62356	01196	63551	37
24	12 48	47 12	36502	98801	37700	62300	01199	63498	36
25	10 12 40	1 47 20	9.36555	9.98798	9.37756	10.62244	10.01202	10.63445	35
26	12 32	47 28	36608	98795	37812	62188	01205	63392	34
27	12 24	47 36	36660	98792	37868	62132	01208	63340	33
28	12 16	47 44	36713	98789	37924	62076	01211	63287	32
29	12 8	47 52	36766	98786	37980	62020	01214	63234	31
30	10 12 0	1 48 0	9.36819	9.98783	9.38035	10.61965	10.01217	10.63181	30
31	11 52	48 8	36871	98780	38091	61909	01220	63129	29
32	11 44	48 16	36924	98777	38147	61853	01223	63076	28
33	11 36	48 24	36976	98774	38202	61798	01226	63024	27
34	11 28	48 32	37028	98771	38257	61743	01229	62972	26
35	10 11 20	1 48 40	9.37081	9.98768	9.38313	10.61687	10.01232	10.62919	25
36	11 12	48 48	37133	98765	38368	61632	01235	62867	24
37	11 4	48 56	37185	98762	38423	61577	01238	62815	23
38	10 56	49 4	37237	98759	38479	61521	01241	62763	22
39	10 48	49 12	37289	98756	38534	61466	01244	62711	21
40	10 10 40	1 49 20	9.37341	9.98753	9.38589	10.61411	10.01247	10.62659	20
41	10 32	49 28	37393	98750	38644	61356	01250	62607	19
42	10 24	49 36	37445	98746	38699	61301	01254	62555	18
43	10 16	49 44	37497	98743	38754	61246	01257	62503	17
44	10 8	49 52	37549	98740	38808	61192	01260	62451	16
45	10 10 0	1 50 0	9.37600	9.98737	9.38863	10.61137	10.01263	10.62400	15
46	9 52	50 8	37652	98734	38918	61082	01266	62348	14
47	9 44	50 16	37703	98731	38972	61028	01269	62297	13
48	9 36	50 24	37755	98728	39027	60973	01272	62245	12
49	9 28	50 32	37806	98725	39082	60918	01275	62194	11
50	10 9 20	1 50 40	9.37858	9.98722	9.39136	10.60864	10.01278	10.62142	10
51	9 12	50 48	37909	98719	39190	60810	01281	62091	9
52	9 4	50 56	37960	98715	39245	60755	01285	62040	8
53	8 56	51 4	38011	98712	39299	60701	01288	61989	7
54	8 48	51 12	38062	98709	39353	60647	01291	61938	6
55	10 8 40	1 51 20	9.38113	9.98706	9.39407	10.60593	10.01294	10.61887	5
56	8 32	51 28	38164	98703	39461	60539	01297	61836	4
57	8 24	51 36	38215	98700	39515	60485	01300	61785	3
58	8 16	51 44	38266	98697	39569	60431	01303	61734	2
59	8 8	51 52	38317	98694	39623	60377	01306	61683	1
60	8 0	52 0	38368	98690	39677	60323	01310	61632	0
M	Hour P.M.	Hour A.M.	Co-sine.	Sine.	Co-tang.	Tangent.	Co-secant	Secant.	M

103 Degs. Degs. 76.

Log. Sines, Tangents and Secants.

18 Degs. Degs. 161.

M	Hour A.M.	Hour P.M.	Sine.	Co-sine.	Tangent.	Co-tang.	Secant.	Co-secant.	M
0	9 36 0	2 24 0	9.48998	9.97821	9.51178	10.48822	10.02179	10.51002	60
1	35 52	24 8	49037	97817	51221	48779	02183	50963	59
2	35 44	24 16	49076	97812	51264	48736	02188	50924	58
3	35 36	24 24	49115	97808	51306	48694	02192	50835	57
4	35 28	24 32	49153	97804	51349	48651	02196	50847	56
5	9 35 20	2 24 40	9.49192	9.97800	9.51392	10.48608	10.02200	10.50808	55
6	35 12	24 48	49231	97796	51435	48565	02204	50769	54
7	35 4	24 56	49269	97792	51478	48522	02208	50731	53
8	34 56	25 4	49308	97788	51520	48480	02212	50692	52
9	34 48	25 12	49347	97784	51563	48437	02216	50653	51
10	9 34 40	2 25 20	9.49385	9.97779	9.51606	10.48394	10.02221	10.50615	50
11	34 32	25 28	49424	97775	51648	48352	02225	50576	49
12	34 24	25 36	49462	97771	51691	48309	02229	50538	48
13	34 16	25 44	49500	97767	51734	48266	02233	50500	47
14	34 8	25 52	49539	97763	51776	48224	02237	50461	46
15	9 34 0	2 26 0	9.49577	9.97759	9.51819	10.48181	10.02241	10.50423	45
16	33 52	26 8	49615	97754	51861	48139	02246	50385	44
17	33 44	26 16	49654	97750	51903	48097	02250	50346	43
18	33 36	26 24	49692	97746	51946	48054	02254	50308	42
19	33 28	26 32	49730	97742	51988	48012	02258	50270	41
20	9 33 20	2 26 40	9.49768	9.97738	9.52031	10.47969	10.02262	10.50232	40
21	33 12	26 48	49806	97734	52073	47927	02266	50194	39
22	33 4	26 56	49844	97729	52115	47885	02271	50156	38
23	32 56	27 4	49882	97725	52157	47843	02275	50118	37
24	32 48	27 12	49920	97721	52200	47800	02279	50080	36
25	9 32 40	2 27 20	9.49958	9.97717	9.52242	10.47758	10.02283	10.50042	35
26	32 32	27 28	49996	97715	52284	47716	02287	50004	34
27	32 24	27 36	50034	97708	52326	47674	02292	49966	33
28	32 16	27 44	50072	97704	52368	47632	02296	49928	32
29	32 8	27 52	50110	97700	52410	47590	02300	49890	31
30	9 32 0	2 28 0	9.50148	9.97696	9.52452	10.47548	10.02304	10.49852	30
31	31 52	28 8	50185	97691	52494	47506	02309	49815	29
32	31 44	28 16	50223	97687	52536	47464	02313	49777	28
33	31 36	28 24	50261	97683	52578	47422	02317	49739	27
34	31 28	28 32	50298	97679	52620	47380	02321	49702	26
35	9 31 20	2 28 40	9.50336	9.97674	9.52661	10.47339	10.02326	10.49664	25
36	31 12	28 48	50374	97670	52703	47297	02330	49626	24
37	31 4	28 56	50411	97666	52745	47255	02334	49589	23
38	30 56	29 4	50449	97662	52787	47213	02338	49551	22
39	30 48	29 12	50486	97657	52829	47171	02343	49514	21
40	9 30 40	2 29 20	9.50523	9.97653	9.52870	10.47130	10.02347	10.49477	20
41	30 32	29 28	50561	97649	52912	47088	02351	49439	19
42	30 24	29 36	50598	97645	52953	47017	02355	49402	18
43	30 16	29 44	50635	97640	52995	47005	02360	49365	17
44	30 8	29 52	50673	97636	53037	46963	02364	49327	16
45	9 30 0	2 30 0	9.50710	9.97632	9.53078	10.46922	10.02368	10.49290	15
46	29 52	30 8	50747	97628	53120	46880	02372	49253	14
47	29 44	30 16	50784	97623	53161	46839	02377	49216	13
48	29 36	30 24	50821	97619	53202	46798	02381	49179	12
49	29 28	30 32	50858	97615	53244	46756	02385	49142	11
50	9 29 20	2 30 40	9.50896	9.97610	9.53285	10.46715	10.02390	10.49104	10
51	29 12	30 48	50933	97606	53327	46673	02394	49067	9
52	29 4	30 56	50970	97602	53368	46632	02398	49030	8
53	28 56	31 4	51007	97597	53409	46591	02403	48993	7
54	28 48	31 12	51043	97593	53450	46550	02407	48957	6
55	9 28 40	2 31 20	9.51080	9.97589	9.53492	10.46508	10.02411	10.48920	5
56	28 32	31 28	51117	97584	53533	46467	02416	48883	4
57	28 24	31 36	51154	97580	53574	46426	02420	48846	3
58	28 16	31 44	51191	97576	53615	46385	02424	48809	2
59	28 8	31 52	51227	97571	53656	46344	02429	48773	1
60	28 0	32 0	51264	97567	53697	46303	02433	48736	0
M	Hour P.M.	Hour A.M.	Co-sine.	Sine.	Co-tang.	Tangent.	Co-secant.	Secant.	M

108 Degs. Degs. 71.

Log. Sines, Tangents and Secants.

23 Degs. Degs. 156.

M	Hours A.M.	Hours P.M.	Sine.	Co-sine.	Tangent.	Co-tang.	Secant.	Co-secant	M
0	8 56 0	3 4 0	9.59188	9.96403	9.62785	10.37215	10.03597	10.40812	60
1	55 52	4 8	59218	96397	62820	37180	03603	40782	59
2	55 44	4 16	59247	96392	62855	37145	03608	40753	58
3	55 36	4 24	59277	96387	62890	37110	03613	40723	57
4	55 28	4 32	59307	96381	62926	37074	03619	40693	56
5	8 55 20	3 4 40	9.59336	9.96376	9.62961	10.37039	10.03624	10.40664	55
6	55 12	4 48	59366	96370	62996	37004	03630	40634	54
7	55 4	4 56	59396	96365	63031	36969	03635	40604	53
8	54 56	5 4	59425	96360	63066	36934	03640	40575	52
9	54 48	5 12	59455	96354	63101	36899	03646	40545	51
10	8 54 40	3 5 20	9.59484	9.96349	9.63135	10.36865	10.03651	10.40516	50
11	54 32	5 28	59514	96343	63170	36830	03657	40486	49
12	54 24	5 36	59543	96338	63205	36795	03662	40457	48
13	54 16	5 44	59573	96333	63240	36760	03667	40427	47
14	54 8	5 52	59602	96327	63275	36725	03673	40398	46
15	8 54 0	3 6 0	9.59632	9.96322	9.63310	10.36690	10.03678	10.40368	45
16	53 52	6 8	59661	96316	63345	36655	03684	40339	44
17	53 44	6 16	59690	96311	63379	36621	03689	40310	43
18	53 36	6 24	59720	96305	63414	36586	03695	40280	42
19	53 28	6 32	59749	96300	63449	36551	03700	40251	41
20	8 53 20	3 6 40	9.59778	9.96294	9.63484	10.36516	10.03706	10.40222	40
21	53 12	6 48	59808	96289	63519	36481	03711	40192	39
22	53 4	6 56	59837	96284	63553	36447	03716	40163	38
23	52 56	7 4	59866	96278	63588	36412	03722	40134	37
24	52 48	7 12	59895	96273	63623	36377	03727	40105	36
25	8 52 40	3 7 20	9.59924	9.96267	9.63657	10.36343	10.03733	10.40076	35
26	52 32	7 28	59954	96262	63692	36308	03738	40046	34
27	52 24	7 36	59983	96256	63726	36274	03744	40017	33
28	52 16	7 44	60012	96251	63761	36239	03749	39988	32
29	52 8	7 52	60041	96245	63796	36204	03755	39959	31
30	8 52 0	3 8 0	9.60070	9.96240	9.63830	10.36170	10.03760	10.39930	30
31	51 52	8 8	60099	96234	63865	36135	03766	39901	29
32	51 44	8 16	60128	96229	63899	36101	03771	39872	28
33	51 36	8 24	60157	96223	63934	36066	03777	39843	27
34	51 28	8 32	60186	96218	63968	36032	03782	39814	26
35	8 51 20	3 8 40	9.60215	9.96212	9.64003	10.35997	10.03788	10.39785	25
36	51 12	8 48	60244	96207	64037	35963	03793	39756	24
37	51 4	8 56	60273	96201	64072	35928	03799	39727	23
38	50 56	9 4	60302	96196	64106	35894	03804	39698	22
39	50 48	9 12	60331	96190	64140	35860	03810	39669	21
40	8 50 40	3 9 20	9.60359	9.96185	9.64175	10.35825	10.03815	10.39641	20
41	50 32	9 28	60388	96179	64209	35791	03821	39612	19
42	50 24	9 36	60417	96174	64243	35757	03826	39583	18
43	50 16	9 44	60446	96168	64278	35722	03832	39554	17
44	50 8	9 52	60474	96162	64312	35688	03838	39526	16
45	8 50 0	3 10 0	9.60503	9.96157	9.64346	10.35654	10.03843	10.39497	15
46	49 52	10 8	60532	96151	64381	35619	03849	39468	14
47	49 44	10 16	60561	96146	64415	35585	03854	39439	13
48	49 36	10 24	60589	96140	64449	35551	03860	39411	12
49	49 28	10 32	60618	96135	64483	35517	03865	39382	11
50	8 49 20	3 10 40	9.60646	9.96129	9.64517	10.35483	10.03871	10.39354	10
51	49 12	10 48	60675	96123	64552	35448	03877	39325	9
52	49 4	10 56	60704	96118	64586	35414	03882	39296	8
53	48 56	11 4	60732	96112	64620	35380	03888	39268	7
54	48 48	11 12	60761	96107	64654	35346	03893	39239	6
55	8 48 40	3 11 20	9.60789	9.96101	9.64688	10.35312	10.03899	10.39211	5
56	48 32	11 28	60818	96095	64722	35278	03905	39182	4
57	48 24	11 36	60846	96090	64756	35244	03910	39154	3
58	48 16	11 44	60875	96084	64790	35210	03916	39125	2
59	48 8	11 52	60903	96079	64824	35176	03921	39097	1
60	48 0	12 0	60931	96073	64858	35142	03927	39069	0
M	Hours P.M.	Hours A.M.	Co-sine.	Sine.	Co-tang.	Tangent.	Co-secant	Secant.	M

TABLE XXVII.

Log. Sines, Tangents and Secants.

27 Degs. | Degs. 152.

M	Hour A.M.	Hour P.M.	Sine.	Co-sine.	Tangent.	Co-tang.	Secant.	Co-secant.	M
0	8 24 0	3 36 0	9.65705	9.94988	9.70717	10.29283	10.05012	10.34295	60
1	23 52	36 8	65729	94982	70748	29252	05018	34271	59
2	23 44	36 16	65754	94975	70779	29221	05025	34246	58
3	23 36	36 24	65779	94969	70810	29190	05031	34221	57
4	23 28	36 32	65804	94962	70841	29159	05038	34196	56
5	8 23 20	3 36 40	9.65828	9.94956	9.70873	10.29127	10.05044	10.34172	55
6	23 12	36 48	65853	94949	70904	29096	05051	34147	54
7	23 4	36 56	65878	94943	70935	29065	05057	34122	53
8	22 56	37 4	65902	94936	70966	29034	05064	34098	52
9	22 48	37 12	65927	94930	70997	29003	05070	34073	51
10	8 22 40	3 37 20	9.65952	9.94923	9.71028	10.28972	10.05077	10.34048	50
11	22 32	37 28	65976	94917	71059	28941	05083	34024	49
12	22 24	37 36	66001	94911	71090	28910	05089	33999	48
13	22 16	37 44	66025	94904	71121	28879	05096	33975	47
14	22 8	37 52	66050	94898	71153	28847	05102	33950	46
15	8 22 0	3 38 0	9.66075	9.94891	9.71184	10.28816	10.05109	10.33925	45
16	21 52	38 8	66099	94885	71215	28785	05115	33901	44
17	21 44	38 16	66124	94878	71246	28754	05122	33876	43
18	21 36	38 24	66148	94871	71277	28723	05129	33852	42
19	21 28	38 32	66173	94865	71308	28692	05135	33827	41
20	8 21 20	3 38 40	9.66197	9.94858	9.71339	10.28661	10.05142	10.33803	40
21	21 12	38 48	66221	94852	71370	28630	05148	33779	39
22	21 4	38 56	66246	94845	71401	28599	05155	33754	38
23	20 56	39 4	66270	94839	71431	28569	05161	33730	37
24	20 48	39 12	66295	94832	71462	28538	05168	33705	36
25	8 20 40	3 39 20	9.66319	9.94826	9.71493	10.28507	10.05174	10.33681	35
26	20 32	39 28	66343	94819	71524	28476	05181	33657	34
27	20 24	39 36	66368	94813	71555	28445	05187	33632	33
28	20 16	39 44	66392	94806	71586	28414	05194	33608	32
29	20 8	39 52	66416	94799	71617	28383	05201	33584	31
30	8 20 0	3 40 0	9.66441	9.94793	9.71648	10.28352	10.05207	10.33559	30
31	19 52	40 8	66465	94786	71679	28321	05214	33535	29
32	19 44	40 16	66489	94780	71709	28291	05220	33511	28
33	19 36	40 24	66513	94773	71740	28260	05227	33487	27
34	19 28	40 32	66537	94767	71771	28229	05233	33463	26
35	8 19 20	3 40 40	9.66562	9.94760	9.71802	10.28198	10.05240	10.33438	25
36	19 12	40 48	66586	94753	71833	28167	05247	33414	24
37	19 4	40 56	66610	94747	71863	28137	05253	33390	23
38	18 56	41 4	66634	94740	71894	28106	05260	33366	22
39	18 48	41 12	66658	94734	71925	28075	05266	33342	21
40	8 18 40	3 41 20	9.66682	9.94727	9.71955	10.28045	10.05273	10.33318	20
41	18 32	41 28	66706	94720	71986	28014	05280	33294	19
42	18 24	41 36	66731	94714	72017	27983	05286	33269	18
43	18 16	41 44	66755	94707	72048	27952	05293	33245	17
44	18 8	41 52	66779	94700	72078	27922	05300	33221	16
45	8 18 0	3 42 0	9.66803	9.94694	9.72109	10.27891	10.05306	10.33197	15
46	17 52	42 8	66827	94687	72140	27860	05313	33173	14
47	17 44	42 16	66851	94680	72170	27830	05320	33149	13
48	17 36	42 24	66875	94674	72201	27799	05326	33125	12
49	17 28	42 32	66899	94667	72231	27769	05333	33101	11
50	8 17 20	3 42 40	9.66922	9.94660	9.72262	10.27738	10.05340	10.33078	10
51	17 12	42 48	66946	94654	72293	27707	05346	33054	9
52	17 4	42 56	66970	94647	72323	27677	05353	33030	8
53	16 56	43 4	66994	94640	72354	27646	05360	33006	7
54	16 48	43 12	67018	94634	72384	27616	05366	32982	6
55	8 16 40	3 43 20	9.67042	9.94627	9.72415	10.27585	10.05373	10.32958	5
56	16 32	43 28	67066	94620	72445	27555	05380	32934	4
57	16 24	43 36	67090	94614	72476	27524	05386	32910	3
58	16 16	43 44	67113	94607	72506	27494	05393	32887	2
59	16 8	43 52	67137	94600	72537	27463	05400	32863	1
60	16 0	44 0	67161	94593	72567	27433	05407	32839	0
M	Hour P.M.	Hour A.M.	Co-sine.	Sine.	Co-tang.	Tangent.	Co-secant.	Secant.	M

117 Degs. | Degs. 62.

TABLE XXVII.

Log. Sines, Tangents and Secants.

30 Deg. | Degs. 149.

M	Hour A.M.	Hour P.M.	Sine.	Co-sine.	Tangent.	Co-tang.	Secant.	Co-secant.	M
0	[illegible]	4 0 0	9.69897	9.93753	9.76144	10.23856	10.06247	10.30103	60
1	7 59 52	0 8	69919	93746	76173	23827	06254	30081	59
2	59 44	0 16	69941	93738	76202	23798	06262	30059	58
3	59 36	0 24	69963	93731	76231	23769	06269	30037	57
4	59 28	0 32	69984	93724	76261	23739	06276	30016	56
5	7 59 20	4 0 40	9.70006	9.93717	9.76290	10.23710	10.06283	10.29994	55
6	59 12	0 48	70028	93709	76319	23681	06291	29972	54
7	59 4	0 56	70050	93702	76348	23652	06298	29950	53
8	58 56	1 4	70072	93695	76377	23623	06305	29928	52
9	58 48	1 12	70093	93687	76406	23594	06313	29907	51
10	7 58 40	4 1 20	9.70115	9.93680	9.76435	10.23565	10.06320	10.29885	50
11	58 32	1 28	70137	93673	76464	23536	06327	29863	49
12	58 24	1 36	70159	93665	76493	23507	06335	29841	48
13	58 16	1 44	70180	93658	76522	23478	06342	29820	47
14	58 8	1 52	70202	93650	76551	23449	06350	29798	46
15	7 58 0	4 2 0	9.70224	9.93643	9.76580	10.23420	10.06357	10.29776	45
16	57 52	2 8	70245	93636	76609	23391	06364	29755	44
17	57 44	2 16	70267	93628	76639	23361	06372	29733	43
18	57 36	2 24	70288	93621	76668	23332	06379	29712	42
19	57 28	2 32	70310	93614	76697	23303	06386	29690	41
20	7 57 20	4 2 40	9.70332	9.93606	9.76725	10.23275	10.06394	10.29668	40
21	57 12	2 48	70353	93599	76754	23246	06401	29647	39
22	57 4	2 56	70375	93591	76783	23217	06409	29625	38
23	56 56	3 4	70396	93584	76812	23188	06416	29604	37
24	56 48	3 12	70418	93577	76841	23159	06423	29582	36
25	7 56 40	4 3 20	9.70439	9.93569	9.76870	10.23130	10.06431	10.29561	35
26	56 32	3 28	70461	93562	76899	23101	06438	29539	34
27	56 24	3 36	70482	93554	76928	23072	06446	29518	33
28	56 16	3 44	70504	93547	76957	23043	06453	29496	32
29	56 8	3 52	70525	93539	76986	23014	06461	29475	31
30	7 56 0	4 4 0	9.70547	9.93532	9.77015	10.22985	10.06468	10.29453	30
31	55 52	4 8	70568	93525	77044	22956	06475	29432	29
32	55 44	4 16	70590	93517	77073	22927	06483	29410	28
33	55 36	4 24	70611	93510	77101	22899	06490	29389	27
34	55 28	4 32	70633	93502	77130	22870	06498	29367	26
35	7 55 20	4 4 40	9.70654	9.93495	9.77159	10.22841	10.06505	10.29346	25
36	55 12	4 48	70675	93487	77188	22812	06513	29325	24
37	55 4	4 56	70697	93480	77217	22783	06520	29303	23
38	54 56	5 4	70718	93472	77246	22754	06528	29282	22
39	54 48	5 12	70739	93465	77274	22726	06535	29261	21
40	7 54 40	4 5 20	9.70761	9.93457	9.77303	10.22697	10.06543	10.29239	20
41	54 32	5 28	70782	93450	77332	22668	06550	29218	19
42	54 24	5 36	70803	93442	77361	22639	06558	29197	18
43	54 16	5 44	70824	93435	77390	22610	06565	29176	17
44	54 8	5 52	70846	93427	77418	22582	06573	29154	16
45	7 54 0	4 6 0	9.70867	9.93420	9.77447	10.22553	10.06580	10.29133	15
46	53 52	6 8	70888	93412	77476	22524	06588	29112	14
47	53 44	6 16	70909	93405	77505	22495	06595	29091	13
48	53 36	6 24	70931	93397	77533	22467	06603	29069	12
49	53 28	6 32	70952	93390	77562	22438	06610	29048	11
50	7 53 20	4 6 40	9.70973	9.93382	9.77591	10.22409	10.06618	10.29027	10
51	53 12	6 48	70994	93375	77619	22381	06625	29006	9
52	53 [illegible]	6 56	71015	93367	77648	22352	06633	28985	8
53	[illegible]	7 4	71036	93360	77677	22323	06640	28964	7
54	[illegible]	7 12	71058	93352	77706	22294	06648	28942	6
55	[illegible]	4 7 20	9.71079	9.93344	9.77734	10.22266	10.06656	10.28921	5
56	52 32	7 28	71100	93337	77763	22237	06663	28900	4
57	52 24	7 36	71121	93329	77791	22209	06671	28879	3
58	[illegible]	7 44	71142	93322	77820	22180	06678	28858	2
59	[illegible]	7 52	71163	93314	77849	22151	06686	28837	1
60	[illegible]	[illegible]	71184	93307	77877	22123	06693	28816	0
M	Hour P.M.	Hour A.M.	Co-sine.	Sine.	Co-tang.	Tangent.	Co-secant.	Secant.	M

[illegible] | Degs. [illegible]

Log. Sines, Tangents and Secants.

31 Degs. Deg. 148.

M	Hour A.M.	Hour P.M.	Sine.	Co-sine.	Tangent.	Co-tang.	Secant.	Co-secant.	M
0	7 52 0	4 8 0	9.71184	9.93307	9.77877	10.22123	10.06693	10.28816	60
1	51 52	8 8	71205	93299	77906	22094	06701	28795	59
2	51 44	8 16	71226	93291	77935	22065	06709	28774	58
3	51 36	8 24	71247	93284	77963	22037	06716	28753	57
4	51 28	8 32	71268	93276	77992	22008	06724	28732	56
5	7 51 20	4 8 40	9.71289	9.93269	9.78020	10.21980	10.06731	10.28711	55
6	51 12	8 48	71310	93261	78049	21951	06739	28690	54
7	51 4	8 56	71331	93253	78077	21923	06747	28669	53
8	50 56	9 4	71352	93246	78106	21894	06754	28648	52
9	50 48	9 12	71373	93238	78135	21865	06762	28627	51
10	7 50 40	4 9 20	9.71393	9.93230	9.78163	10.21837	10.06770	10.28607	50
11	50 32	9 28	71414	93223	78192	21808	06777	28586	49
12	50 24	9 36	71435	93215	78220	21780	06785	28565	48
13	50 16	9 44	71456	93207	78249	21751	06793	28544	47
14	50 8	9 52	71477	93200	78277	21723	06800	28523	46
15	7 50 0	4 10 0	9.71498	9.93192	9.78306	10.21694	10.06808	10.28502	45
16	49 52	10 8	71519	93184	78334	21666	06816	28481	44
17	49 44	10 16	71539	93177	78363	21637	06823	28461	43
18	49 36	10 24	71560	93169	78391	21609	06831	28440	42
19	49 28	10 32	71581	93161	78419	21581	06839	28419	41
20	7 49 20	4 10 40	9.71602	9.93154	9.78448	10.21552	10.06846	10.28398	40
21	49 12	10 48	71622	93146	78476	21524	06854	28378	39
22	49 4	10 56	71643	93138	78505	21495	06862	28357	38
23	48 56	11 4	71664	93131	78533	21467	06869	28336	37
24	48 48	11 12	71685	93123	78562	21438	06877	28315	36
25	7 48 40	4 11 20	9.71705	9.93115	9.78590	10.21410	10.06885	10.28295	35
26	48 32	11 28	71726	93108	78618	21382	06892	28274	34
27	48 24	11 36	71747	93100	78647	21353	06900	28253	33
28	48 16	11 44	71767	93092	78675	21325	06908	28233	32
29	48 8	11 52	71788	93084	78704	21296	06916	28212	31
30	7 48 0	4 12 0	9.71809	9.93077	9.78732	10.21268	10.06923	10.28191	30
31	47 52	12 8	71829	93069	78760	21240	06931	28171	29
32	47 44	12 16	71850	93061	78789	21211	06939	28150	28
33	47 36	12 24	71870	93053	78817	21183	06947	28130	27
34	47 28	12 32	71891	93046	78845	21155	06954	28109	26
35	7 47 20	4 12 40	9.71911	9.93038	9.78874	10.21126	10.06962	10.28089	25
36	47 12	12 48	71932	93030	78902	21098	06970	28068	24
37	47 4	12 56	71952	93022	78930	21070	06978	28048	23
38	46 56	13 4	71973	93014	78959	21041	06986	28027	22
39	46 48	13 12	71994	93007	78987	21013	06993	28006	21
40	7 46 40	4 13 20	9.72014	9.92999	9.79015	10.20985	10.07001	10.27986	20
41	46 32	13 28	72034	92991	79043	20957	07009	27966	19
42	46 24	13 36	72055	92983	79072	20928	07017	27945	18
43	46 16	13 44	72075	92976	79100	20900	07024	27925	17
44	46 8	13 52	72096	92968	79128	20872	07032	27904	16
45	7 46 0	4 14 0	9.72116	9.92960	9.79156	10.20844	10.07040	10.27884	15
46	45 52	14 8	72137	92952	79185	20815	07048	27863	14
47	45 44	14 16	72157	92944	79213	20787	07056	27843	13
48	45 36	14 24	72177	92936	79241	20759	07064	27823	12
49	45 28	14 32	72198	92929	79269	20731	07071	27802	11
50	7 45 20	4 14 40	9.72218	9.92921	9.79297	10.20703	10.07079	10.27782	10
51	45 12	14 48	72238	92913	79326	20674	07087	27762	9
52	45 4	14 56	72259	92905	79354	20646	07095	27741	8
53	44 56	15 4	72279	92897	79382	20618	07103	27721	7
54	44 48	15 12	72299	92889	79410	20590	07111	27701	6
55	7 44 40	4 15 20	9.72320	9.92881	9.79438	10.20562	10.07119	10.27680	5
56	44 32	15 28	72340	92874	79466	20534	07126	27660	4
57	44 24	15 36	72360	92866	79495	20505	07134	27640	3
58	44 16	15 44	72381	92858	79523	20477	07142	27619	2
59	44 8	15 52	72401	92850	79551	20449	07150	27599	1
60	44 0	16 0	72421	92842	79579	20421	07158	27579	0
M	Hour P.M.	Hour A.M.	Co-sine.	Sine.	Co-tang.	Tangent.	Co-secant.	Secant.	M

121 Degs. Degs. 58.

TABLE XXVII.

Log. Sines, Tangents and Secants.

36 Degs. Degs. 143.

M	Hour A.M.	Hour P.M.	Sine.	Co-sine.	Tangent.	Co-tang.	Secant.	Co-secant	M
0	7 12 0	4 48 0	9.76922	9.90796	9.86126	10.13874	10.09204	10.23078	60
1	11 52	48 8	76939	90787	86153	13847	09213	23061	59
2	11 44	48 16	76957	90777	86179	13821	09223	23043	58
3	11 36	48 24	76974	90768	86206	13794	09232	23026	57
4	11 28	48 32	76991	90759	86232	13768	09241	23009	56
5	7 11 20	4 48 40	9.77009	9.90750	9.86259	10.13741	10.09250	10.22991	55
6	11 12	48 48	77026	90741	86285	13715	09259	22974	54
7	11 4	48 56	77043	90731	86312	13688	09269	22957	53
8	10 56	49 4	77061	90722	86338	13662	09278	22939	52
9	10 48	49 12	77078	90713	86365	13635	09287	22922	51
10	7 10 40	4 49 20	9.77095	9.90704	9.86392	10.13608	10.09296	10.22905	50
11	10 32	49 28	77112	90694	86418	13582	09306	22888	49
12	10 24	49 36	77130	90685	86445	13555	09315	22870	48
13	10 16	49 44	77147	90676	86471	13529	09324	22853	47
14	10 8	49 52	77164	90667	86498	13502	09333	22836	46
15	7 10 0	4 50 0	9.77181	9.90657	9.86524	10.13476	10.09343	10.22819	45
16	9 52	50 8	77199	90648	86551	13449	09352	22801	44
17	9 44	50 16	77216	90639	86577	13423	09361	22784	43
18	9 36	50 24	77233	90630	86603	13397	09370	22767	42
19	9 28	50 32	77250	90620	86630	13370	09380	22750	41
20	7 9 20	4 50 40	9.77268	9.90611	9.86656	10.13344	10.09389	10.22732	40
21	9 12	50 48	77285	90602	86683	13317	09398	22715	39
22	9 4	50 56	77302	90592	86709	13291	09408	22698	38
23	8 56	51 4	77319	90583	86736	13264	09417	22681	37
24	8 48	51 12	77336	90574	86762	13238	09426	22664	36
25	7 8 40	4 51 20	9.77353	9.90565	9.86789	10.13211	10.09435	10.22647	35
26	8 32	51 28	77370	90555	86815	13185	09445	22630	34
27	8 24	51 36	77387	90546	86842	13158	09454	22613	33
28	8 16	51 44	77405	90537	86868	13132	09463	22595	32
29	8 8	51 52	77422	90527	86894	13106	09473	22578	31
30	7 8 0	4 52 0	9.77439	9.90518	9.86921	10.13079	10.09482	10.22561	30
31	7 52	52 8	77456	90509	86947	13053	09491	22544	29
32	7 44	52 16	77473	90499	86974	13026	09501	22527	28
33	7 36	52 24	77490	90490	87000	13000	09510	22510	27
34	7 28	52 32	77507	90480	87027	12973	09520	22493	26
35	7 7 20	4 52 40	9.77524	9.90471	9.87053	10.12947	10.09529	10.22476	25
36	7 12	52 48	77541	90462	87079	12921	09538	22459	24
37	7 4	52 56	77558	90452	87106	12894	09548	22442	23
38	6 56	53 4	77575	90443	87132	12868	09557	22425	22
39	6 48	53 12	77592	90434	87158	12842	09566	22408	21
40	7 6 40	4 53 20	9.77609	9.90424	9.87185	10.12815	10.09576	10.22391	20
41	6 32	53 28	77626	90415	87211	12789	09585	22374	19
42	6 24	53 36	77643	90405	87238	12762	09595	22357	18
43	6 16	53 44	77660	90396	87264	12736	09604	22340	17
44	6 8	53 52	77677	90386	87290	12710	09614	22323	16
45	7 6 0	4 54 0	9.77694	9.90377	9.87317	10.12683	10.09623	10.22306	15
46	5 52	54 8	77711	90368	87343	12657	09632	22289	14
47	5 44	54 16	77728	90358	87369	12631	09642	22272	13
48	5 36	54 24	77744	90349	87396	12604	09651	22256	12
49	5 28	54 32	77761	90339	87422	12578	09661	22239	11
50	7 5 20	4 54 40	9.77778	9.90330	9.87448	10.12552	10.09670	10.22222	10
51	5 12	54 48	77795	90320	87475	12525	09680	22205	9
52	5 4	54 56	77812	90311	87501	12499	09689	22188	8
53	4 56	55 4	77829	90301	87527	12473	09699	22171	7
54	4 48	55 12	77846	90292	87554	12446	09708	22154	6
55	7 4 40	4 55 20	9.77862	9.90282	9.87580	10.12420	10.09718	10.22138	5
56	4 32	55 28	77879	90273	87606	12394	09727	22121	4
57	4 24	55 36	77896	90263	87633	12367	09737	22104	3
58	4 16	55 44	77913	90254	87659	12341	09746	22087	2
59	4 8	55 52	77930	90244	87685	12315	09756	22070	1
60	4 0	56 0	77946	90235	87711	12289	09765	22054	0
M	Hour P.M.	Hour A.M.	Co-sine.	Sine.	Co-tang.	Tangent.	Co-secant	Secant.	M

126 Degs. Degs. 53

Log. Sines, Tangents and Secants.

37 Degs. Degs. 142.

M	Hour A.M.	Hour P.M.	Sine.	Co-sine.	Tangent.	Co-tang.	Secant.	Co-secant	M
0	7 4 0	4 56 0	9.77946	9.90235	9.87711	10.12289	10.09765	10.22054	60
1	3 52	56 8	77963	90225	87738	12262	09775	22037	59
2	3 44	56 16	77980	90216	87764	12236	09784	22020	58
3	3 36	56 24	77997	90206	87790	12210	09794	22003	57
4	3 28	56 32	78013	90197	87817	12183	09803	21987	56
5	7 3 20	4 56 40	9.78030	9.90187	9.87843	10.12157	10.09813	10.21970	55
6	3 12	56 48	78047	90178	87869	12131	09822	21953	54
7	3 4	56 56	78063	90168	87895	12105	09832	21937	53
8	2 56	57 4	78080	90159	87922	12078	09841	21920	52
9	2 48	57 12	78097	90149	87948	12052	09851	21903	51
10	7 2 40	4 57 20	9.78113	9.90139	9.87974	10.12026	10.09861	10.21887	50
11	2 32	57 28	78130	90130	88000	12000	09870	21870	49
12	2 24	57 36	78147	90120	88027	11973	09880	21853	48
13	2 16	57 44	78163	90111	88053	11947	09889	21837	47
14	2 8	57 52	78180	90101	88079	11921	09899	21820	46
15	7 2 0	4 58 0	9.78197	9.90091	9.88105	10.11895	10.09909	10.21803	45
16	1 52	58 8	78213	90082	88131	11869	09918	21787	44
17	1 44	58 16	78230	90072	88158	11842	09928	21770	43
18	1 36	58 24	78246	90063	88184	11816	09937	21754	42
19	1 28	58 32	78263	90053	88210	11790	09947	21737	41
20	7 1 20	4 58 40	9.78280	9.90043	9.88236	10.11764	10.09957	10.21720	40
21	1 12	58 48	78296	90034	88262	11738	09966	21704	39
22	1 4	58 56	78313	90024	88289	11711	09976	21687	38
23	0 56	59 4	78329	90014	88315	11685	09986	21671	37
24	0 48	59 12	78346	90005	88341	11659	09995	21654	36
25	7 0 40	4 59 20	9.78362	9.89995	9.88367	10.11633	10.10005	10.21638	35
26	0 32	59 28	78379	89985	88393	11607	10015	21621	34
27	0 24	59 36	78395	89976	88420	11580	10024	21605	33
28	0 16	59 44	78412	89966	88446	11554	10034	21588	32
29	0 8	59 52	78428	89956	88472	11528	10044	21572	31
30	7 0 0	5 0 0	9.78445	9.89947	9.88498	10.11502	10.10053	10.21555	30
31	6 59 52	0 8	78461	89937	88524	11476	10063	21539	29
32	59 44	0 16	78478	89927	88550	11450	10073	21522	28
33	59 36	0 24	78494	89918	88577	11423	10082	21506	27
34	59 28	0 32	78510	89908	88603	11397	10092	21490	26
35	6 59 20	5 0 40	9.78527	9.89898	9.88629	10.11371	10.10102	10.21473	25
36	59 12	0 48	78543	89888	88655	11345	10112	21457	24
37	59 4	0 56	78560	89879	88681	11319	10121	21440	23
38	58 56	1 4	78576	89869	88707	11293	10131	21424	22
39	58 48	1 12	78592	89859	88733	11267	10141	21408	21
40	6 58 40	5 1 20	9.78609	9.89849	9.88759	10.11241	10.10151	10.21391	20
41	58 32	1 28	78625	89840	88786	11214	10160	21375	19
42	58 24	1 36	78642	89830	88812	11188	10170	21358	18
43	58 16	1 44	78658	89820	88838	11162	10180	21342	17
44	58 8	1 52	78674	89810	88864	11136	10190	21326	16
45	6 58 0	5 2 0	9.78691	9.89801	9.88890	10.11110	10.10199	10.21309	15
46	57 52	2 8	78707	89791	88916	11084	10209	21293	14
47	57 44	2 16	78723	89781	88942	11058	10219	21277	13
48	57 36	2 24	78739	89771	88968	11032	10229	21261	12
49	57 28	2 32	78756	89761	88994	11006	10239	21244	11
50	6 57 20	5 2 40	9.78772	9.89752	9.89020	10.10980	10.10248	10.21228	10
51	57 12	2 48	78788	89742	89046	10954	10258	21212	9
52	57 4	2 56	78805	89732	89073	10927	10268	21195	8
53	56 56	3 4	78821	89722	89099	10901	10278	21179	7
54	56 48	3 12	78837	89712	89125	10875	10288	21163	6
55	6 56 40	5 3 20	9.78853	9.89702	9.89151	10.10849	10.10298	10.21147	5
56	56 32	3 28	78869	89693	89177	10823	10307	21131	4
57	56 24	3 36	78886	89683	89203	10797	10317	21114	3
58	56 16	3 44	78902	89673	89229	10771	10327	21098	2
59	56 8	3 52	78918	89663	89255	10745	10337	21082	1
60	56 0	4 0	78934	89653	89281	10719	10347	21066	0
M	Hour P.M.	Hour A.M.	Co-sine.	Sine.	Co-tang.	Tangent.	Co-secant	Secant.	M

127 Degs. Degs. 52.

TABLE XXVII.

Log. Sines, Tangents and Secants.

39 Degs. Deg. 140.

M	Hour A.M.	Hour P.M.	Sine.	Co-sine.	Tangent.	Co-tang.	Secant.	Co-secant.	M
0	6 48 0	5 12 0	9.79887	9.89050	9.90837	10.09163	10.10950	10.20113	60
1	47 52	12 8	79903	89040	90863	09137	10960	20097	59
2	47 44	12 16	79918	89030	90889	09111	10970	20082	58
3	47 36	12 24	79934	89020	90914	09086	10980	20066	57
4	47 28	12 32	79950	89009	90940	09060	10991	20050	56
5	6 47 20	5 12 40	9.79965	9.88999	9.90966	10.09034	10.11001	10.20035	55
6	47 12	12 48	79981	88989	90992	09008	11011	20019	54
7	47 4	12 56	79996	88978	91018	08982	11022	20004	53
8	46 56	13 4	80012	88968	91043	08957	11032	19988	52
9	46 48	13 12	80027	88958	91069	08931	11042	19973	51
10	6 46 40	5 13 20	9.80043	9.88948	9.91095	10.08905	10.11052	10.19957	50
11	46 32	13 28	80058	88937	91121	08879	11063	19942	49
12	46 24	13 36	80074	88927	91147	08853	11073	19926	48
13	46 16	13 44	80089	88917	91172	08828	11083	19911	47
14	46 8	13 52	80105	88906	91198	08802	11094	19895	46
15	6 46 0	5 14 0	9.80120	9.88896	9.91224	10.08776	10.11104	10.19880	45
16	45 52	14 8	80136	88886	91250	08750	11114	19864	44
17	45 44	14 16	80151	88875	91276	08724	11125	19849	43
18	45 36	14 24	80166	88865	91301	08699	11135	19834	42
19	45 28	14 32	80182	88855	91327	08673	11145	19818	41
20	6 45 20	5 14 40	9.80197	9.88844	9.91353	10.08647	10.11156	10.19803	40
21	45 12	14 48	80213	88834	91379	08621	11166	19787	39
22	45 4	14 56	80228	88824	91404	08596	11176	19772	38
23	44 56	15 4	80244	88813	91430	08570	11187	19756	37
24	44 48	15 12	80259	88803	91456	08544	11197	19741	36
25	6 44 40	5 15 20	9.80274	9.88793	9.91482	10.08518	10.11207	10.19726	35
26	44 32	15 28	80290	88782	91507	08493	11218	19710	34
27	44 24	15 36	80305	88772	91533	08467	11228	19695	33
28	44 16	15 44	80320	88761	91559	08441	11239	19680	32
29	44 8	15 52	80336	88751	91585	08415	11249	19664	31
30	6 44 0	5 16 0	9.80351	9.88741	9.91610	10.08390	10.11259	10.19649	30
31	43 52	16 8	80366	88730	91636	08364	11270	19634	29
32	43 44	16 16	80382	88720	91662	08338	11280	19618	28
33	43 36	16 24	80397	88709	91688	08312	11291	19603	27
34	43 28	16 32	80412	88699	91713	08287	11301	19588	26
35	6 43 20	5 16 40	9.80428	9.88688	9.91739	10.08261	10.11312	10.19572	25
36	43 12	16 48	80443	88678	91765	08235	11322	19557	24
37	43 4	16 56	80458	88668	91791	08209	11332	19542	23
38	42 56	17 4	80473	88657	91816	08184	11343	19527	22
39	42 48	17 12	80489	88647	91842	08158	11353	19511	21
40	6 42 40	5 17 20	9.80504	9.88636	9.91868	10.08132	10.11364	10.19496	20
41	42 32	17 28	80519	88626	91893	08107	11374	19481	19
42	42 24	17 36	80534	88615	91919	08081	11385	19466	18
43	42 16	17 44	80550	88605	91945	08055	11395	19450	17
44	42 8	17 52	80565	88594	91971	08029	11406	19435	16
45	6 42 0	5 18 0	9.80580	9.88584	9.91996	10.08004	10.11416	10.19420	15
46	41 52	18 8	80595	88573	92022	07978	11427	19405	14
47	41 44	18 16	80610	88563	92048	07952	11437	19390	13
48	41 36	18 24	80625	88552	92073	07927	11448	19375	12
49	41 28	18 32	80641	88542	92099	07901	11458	19359	11
50	6 41 20	5 18 40	9.80656	9.88531	9.92125	10.07875	10.11469	10.19344	10
51	41 12	18 48	80671	88521	92150	07850	11479	19329	9
52	41 4	18 56	80686	88510	92176	07824	11490	19314	8
53	40 56	19 4	80701	88499	92202	07798	11501	19299	7
54	40 48	19 12	80716	88489	92227	07773	11511	19284	6
55	6 40 40	5 19 20	9.80731	9.88478	9.92253	10.07747	10.11522	10.19269	5
56	40 32	19 28	80746	88468	92279	07721	11532	19254	4
57	40 24	19 36	80762	88457	92304	07696	11543	19238	3
58	40 16	19 44	80777	88447	92330	07670	11553	19223	2
59	40 8	19 52	80792	88436	92356	07644	11564	19208	1
60	40 0	20 0	80807	88425	92381	07619	11575	19193	0
M	Hour P.M.	Hour A.M.	Co-sine.	Sine.	Co-tang.	Tangent.	Co-secant.	Secant.	M

TABLE XXVII.

Log. Sines, Tangents and Secants.

40 Degs. Degs. 139.

M	Hour A.M.	Hour P.M.	Sine.	Co-sine.	Tangent.	Co-tang.	Secant.	Co-secant.	M
0	6 40 0	5 20 0	9.80807	9.88425	9.92381	10.07619	10.11575	10.19193	60
1	39 52	20 8	80822	88415	92407	07593	11585	19178	59
2	39 44	20 16	80837	88404	92433	07567	11596	19163	58
3	39 36	20 24	80852	88394	92458	07542	11606	19148	57
4	39 28	20 32	80867	88383	92484	07516	11617	19133	56
5	6 39 20	5 20 40	9.80882	9.88372	9.92510	10.07490	10.11628	10.19118	55
6	39 12	20 48	80897	88362	92535	07465	11638	19103	54
7	39 4	20 56	80912	88351	92561	07439	11649	19088	53
8	38 56	21 4	80927	88340	92587	07413	11660	19073	52
9	38 48	21 12	80942	88330	92612	07388	11670	19058	51
10	6 38 40	5 21 20	9.80957	9.88319	9.92638	10.07362	10.11681	10.19043	50
11	38 32	21 28	80972	88308	92663	07337	11692	19028	49
12	38 24	21 36	80987	88298	92689	07311	11702	19013	48
13	38 16	21 44	81002	88287	92715	07285	11713	18998	47
14	38 8	21 52	81017	88276	92740	07260	11724	18983	46
15	6 38 0	5 22 0	9.81032	9.88266	9.92766	10.07234	10.11734	10.18968	45
16	37 52	22 8	81047	88255	92792	07208	11745	18953	44
17	37 44	22 16	81061	88244	92817	07183	11756	18939	43
18	37 36	22 24	81076	88234	92843	07157	11766	18924	42
19	37 28	22 32	81091	88223	92868	07132	11777	18909	41
20	6 37 20	5 22 40	9.81106	9.88212	9.92894	10.07106	10.11788	10.18894	40
21	37 12	22 48	81121	88201	92920	07080	11799	18879	39
22	37 4	22 56	81136	88191	92945	07055	11809	18864	38
23	36 56	23 4	81151	88180	92971	07029	11820	18849	37
24	36 48	23 12	81166	88169	92996	07004	11831	18834	36
25	6 36 40	5 23 20	9.81180	9.88158	9.93022	10.06978	10.11842	10.18820	35
26	36 32	23 28	81195	88148	93048	06952	11852	18805	34
27	36 24	23 36	81210	88137	93073	06927	11863	18790	33
28	36 16	23 44	81225	88126	93099	06901	11874	18775	32
29	36 8	23 52	81240	88115	93124	06876	11885	18760	31
30	6 36 0	5 24 0	9.81254	9.88105	9.93150	10.06850	10.11895	10.18746	30
31	35 52	24 8	81269	88094	93175	06825	11906	18731	29
32	35 44	24 16	81284	88083	93201	06799	11917	18716	28
33	35 36	24 24	81299	88072	93227	06773	11928	18701	27
34	35 28	24 32	81314	88061	93252	06748	11939	18686	26
35	6 35 20	5 24 40	9.81328	9.88051	9.93278	10.06722	10.11949	10.18672	25
36	35 12	24 48	81343	88040	93303	06697	11960	18657	24
37	35 4	24 56	81358	88029	93329	06671	11971	18642	23
38	34 56	25 4	81372	88018	93354	06646	11982	18628	22
39	34 48	25 12	81387	88007	93380	06620	11993	18613	21
40	6 34 40	5 25 20	9.81402	9.87996	9.93406	10.06594	10.12004	10.18598	20
41	34 32	25 28	81417	87985	93431	06569	12015	18583	19
42	34 24	25 36	81431	87975	93457	06543	12025	18569	18
43	34 16	25 44	81446	87964	93482	06518	12036	18554	17
44	34 8	25 52	81461	87953	93508	06492	12047	18539	16
45	6 34 0	5 26 0	9.81475	9.87942	9.93533	10.06467	10.12058	10.18525	15
46	33 52	26 8	81490	87931	93559	06441	12069	18510	14
47	33 44	26 16	81505	87920	93584	06416	12080	18495	13
48	33 36	26 24	81519	87909	93610	06390	12091	18481	12
49	33 28	26 32	81534	87898	93636	06364	12102	18466	11
50	6 33 20	5 26 40	9.81549	9.87887	9.93661	10.06339	10.12113	10.18451	10
51	33 12	26 48	81563	87877	93687	06313	12123	18437	9
52	33 4	26 56	81578	87866	93712	06288	12134	18422	8
53	32 56	27 4	81592	87855	93738	06262	12145	18408	7
54	32 48	27 12	81607	87844	93763	06237	12156	18393	6
55	6 32 40	5 27 20	9.81622	9.87833	9.93789	10.06211	10.12167	10.18378	5
56	32 32	27 28	81636	87822	93814	06186	12178	18364	4
57	32 24	27 36	81651	87811	93840	06160	12189	18349	3
58	32 16	27 44	81665	87800	93865	06135	12200	18335	2
59	32 8	27 52	81680	87789	93891	06109	12211	18320	1
60	32 0	28 0	81694	87778	93916	06084	12222	18306	0
M	Hour P.M.	Hour A.M.	Co-sine.	Sine.	Co-tang.	Tangent.	Co-secant.	Secant.	M

130 Degs. Degs. 49.

TABLE XXVII.

Log. Sines, Tangents and Secants.

42 Degs. Degs. 137.

M	Hour A.M.	Hour P.M.	Sine.	Co-sine.	Tangent.	Co-tang.	Secant.	Co-secant.	M
0	6 24 0	5 36 0	9.82551	9.87107	9.95444	10.04556	10.12893	10.17449	60
1	23 52	36 8	82565	87096	95469	04531	12904	17435	59
2	23 44	36 16	82579	87085	95495	04505	12915	17421	58
3	23 36	36 24	82593	87073	95520	04480	12927	17407	57
4	23 28	36 32	82607	87062	95545	04455	12938	17393	56
5	6 23 20	5 36 40	9.82621	9.87050	9.95571	10.04429	10.12950	10.17379	55
6	23 12	36 48	82635	87039	95596	04404	12961	17365	54
7	23 4	36 56	82649	87028	95622	04378	12972	17351	53
8	22 56	37 4	82663	87016	95647	04353	12984	17337	52
9	22 48	37 12	82677	87005	95672	04328	12995	17323	51
10	6 22 40	5 37 20	9.82691	9.86993	9.95698	10.04302	10.13007	10.17309	50
11	22 32	37 28	82705	86982	95723	04277	13018	17295	49
12	22 24	37 36	82719	86970	95748	04252	13030	17281	48
13	22 16	37 44	82733	86959	95774	04226	13041	17267	47
14	22 8	37 52	82747	86947	95799	04201	13053	17253	46
15	6 22 0	5 38 0	9.82761	9.86936	9.95825	10.04175	10.13064	10.17239	45
16	21 52	38 8	82775	86924	95850	04150	13076	17225	44
17	21 44	38 16	82788	86913	95875	04125	13087	17212	43
18	21 36	38 24	82802	86902	95901	04099	13098	17198	42
19	21 28	38 32	82816	86890	95926	04074	13110	17184	41
20	6 21 20	5 38 40	9.82830	9.86879	9.95952	10.04048	10.13121	10.17170	40
21	21 12	38 48	82844	86867	95977	04023	13133	17156	39
22	21 4	38 56	82858	86855	96002	03998	13145	17142	38
23	20 56	39 4	82872	86844	96028	03972	13156	17128	37
24	20 48	39 12	82885	86832	96053	03947	13168	17115	36
25	6 20 40	5 39 20	9.82899	9.86821	9.96078	10.03922	10.13179	10.17101	35
26	20 32	39 28	82913	86809	96104	03896	13191	17087	34
27	20 24	39 36	82927	86798	96129	03871	13202	17073	33
28	20 16	39 44	82941	86786	96155	03845	13214	17059	32
29	20 8	39 52	82955	86775	96180	03820	13225	17045	31
30	6 20 0	5 40 0	9.82968	9.86763	9.96205	10.03795	10.13237	10.17032	30
31	19 52	40 8	82982	86752	96231	03769	13248	17018	29
32	19 44	40 16	82996	86740	96256	03744	13260	17004	28
33	19 36	40 24	83010	86728	96281	03719	13272	16990	27
34	19 28	40 32	83023	86717	96307	03693	13283	16977	26
35	6 19 20	5 40 40	9.83037	9.86705	9.96332	10.03668	10.13295	10.16963	25
36	19 12	40 48	83051	86694	96357	03643	13306	16949	24
37	19 4	40 56	83065	86682	96383	03617	13318	16935	23
38	18 56	41 4	83078	86670	96408	03592	13330	16922	22
39	18 48	41 12	83092	86659	96433	03567	13341	16908	21
40	6 18 40	5 41 20	9.83106	9.86647	9.96459	10.03541	10.13353	10.16894	20
41	18 32	41 28	83120	86635	96484	03516	13365	16880	19
42	18 24	41 36	83133	86624	96510	03490	13376	16867	18
43	18 16	41 44	83147	86612	96535	03465	13388	16853	17
44	18 8	41 52	83161	86600	96560	03440	13400	16839	16
45	6 18 0	5 42 0	9.83174	9.86589	9.96586	10.03414	10.13411	10.16826	15
46	17 52	42 8	83188	86577	96611	03389	13423	16812	14
47	17 44	42 16	83202	86565	96636	03364	13435	16798	13
48	17 36	42 24	83215	86554	96662	03338	13446	16785	12
49	17 28	42 32	83229	86542	96687	03313	13458	16771	11
50	6 17 20	5 42 40	9.83242	9.86530	9.96712	10.03288	10.13470	10.16758	10
51	17 12	42 48	83256	86518	96738	03262	13482	16744	9
52	17 4	42 56	83270	86507	96763	03237	13493	16730	8
53	16 56	43 4	83283	86495	96788	03212	13505	16717	7
54	16 48	43 12	83297	86483	96814	03186	13517	16703	6
55	6 16 40	5 43 20	9.83310	9.86472	9.96839	10.03161	10.13528	10.16690	5
56	16 32	43 28	83324	86460	96864	03136	13540	16676	4
57	16 24	43 36	83338	86448	96890	03110	13552	16662	3
58	16 16	43 44	83351	86436	96915	03085	13564	16649	2
59	16 8	43 52	83365	86425	96940	03060	13575	16635	1
60	16 0	44 0	83378	86413	96966	03034	13587	16622	0
M	Hour P.M.	Hour A.M.	Co-sine.	Sine.	Co-tang.	Tangent.	Co-secant.	Secant.	M

132 Degs. Degs. 47.

TABLE XXX.

For reducing the Moon's Declination, as given in the Nautical Almanac for Noon and Midnight at Greenwich, to any other time under any other Meridian.

TABLE XXX.

For reducing the Moon's Declination, as given in the Nautical Almanac for Noon and Midnight at Greenwich, to any other time under any other Meridian.

Time from Noon.	Variation of the Moon's Declination in twelve Hours.											Time from Noon.
	° ′ 2 0	° ′ 2 5	° ′ 2 10	° ′ 2 15	° ′ 2 20	° ′ 2 25	° ′ 2 30	° ′ 2 35	° ′ 2 40	° ′ 2 45	° ′ 2 50	
0h 0′	0° 0′	0° 0′	0° 0′	0° 0′	0° 0′	0° 0′	0° 0′	0° 0′	0° 0′	0° 0′	0° 0′	12h 0′
0 12	0 2	0 2	0 2	0 2	0 2	0 2	0 2	0 3	0 3	0 3	0 3	12 12
0 24	0 4	0 4	0 4	0 4	0 5	0 5	0 5	0 5	0 5	0 5	0 6	12 24
0 36	0 6	0 6	0 6	0 7	0 7	0 7	0 7	0 8	0 8	0 8	0 8	12 36
0 48	0 8	0 8	0 9	0 9	0 9	0 10	0 10	0 10	0 11	0 11	0 11	12 48
1 0	0 10	0 10	0 11	0 11	0 12	0 12	0 12	0 13	0 13	0 14	0 14	13 0
1 12	0 12	0 12	0 13	0 13	0 14	0 14	0 15	0 15	0 16	0 16	0 17	13 12
1 24	0 14	0 15	0 15	0 16	0 16	0 17	0 17	0 18	0 19	0 19	0 20	13 24
1 36	0 16	0 17	0 17	0 18	0 19	0 19	0 20	0 21	0 21	0 22	0 23	13 36
1 48	0 18	0 19	0 19	0 20	0 21	0 22	0 22	0 23	0 24	0 25	0 25	13 48
2 0	0 20	0 21	0 22	0 22	0 23	0 24	0 25	0 26	0 27	0 27	0 28	14 0
2 12	0 22	0 23	0 24	0 25	0 26	0 27	0 27	0 28	0 29	0 30	0 31	14 12
2 24	0 24	0 25	0 26	0 27	0 28	0 29	0 30	0 31	0 32	0 33	0 34	14 24
2 36	0 26	0 27	0 28	0 29	0 30	0 31	0 32	0 34	0 35	0 36	0 37	14 36
2 48	0 28	0 29	0 30	0 31	0 33	0 34	0 35	0 36	0 37	0 38	0 40	14 48
3 0	0 30	0 31	0 32	0 34	0 35	0 36	0 37	0 39	0 40	0 41	0 42	15 0
3 12	0 32	0 33	0 35	0 36	0 37	0 39	0 40	0 41	0 43	0 44	0 45	15 12
3 24	0 34	0 35	0 37	0 38	0 40	0 41	0 42	0 44	0 45	0 47	0 48	15 24
3 36	0 36	0 37	0 39	0 40	0 42	0 43	0 45	0 46	0 48	0 49	0 51	15 36
3 48	0 38	0 40	0 41	0 43	0 44	0 46	0 47	0 49	0 51	0 52	0 54	15 48
4 0	0 40	0 42	0 43	0 45	0 47	0 48	0 50	0 52	0 53	0 55	0 57	16 0
4 12	0 42	0 44	0 45	0 47	0 49	0 51	0 52	0 54	0 56	0 58	0 59	16 12
4 24	0 44	0 46	0 48	0 49	0 51	0 53	0 55	0 57	0 59	1 0	1 2	16 24
4 36	0 46	0 48	0 50	0 52	0 54	0 56	0 57	0 59	1 1	1 3	1 5	16 36
4 48	0 48	0 50	0 52	0 54	0 56	0 58	1 0	1 2	1 4	1 6	1 8	16 48
5 0	0 50	0 52	0 54	0 56	0 58	1 0	1 2	1 5	1 7	1 9	1 11	17 0
5 12	0 52	0 54	0 56	0 58	1 1	1 3	1 5	1 7	1 9	1 11	1 14	17 12
5 24	0 54	0 56	0 58	1 1	1 3	1 5	1 7	1 10	1 12	1 14	1 16	17 24
5 36	0 56	0 58	1 1	1 3	1 5	1 8	1 10	1 12	1 15	1 17	1 19	17 36
5 48	0 58	1 0	1 3	1 5	1 8	1 10	1 12	1 15	1 17	1 20	1 22	17 48
6 0	1 0	1 2	1 5	1 7	1 10	1 12	1 15	1 17	1 20	1 22	1 25	18 0
6 12	1 2	1 5	1 7	1 10	1 12	1 15	1 17	1 20	1 23	1 25	1 28	18 12
6 24	1 4	1 7	1 9	1 12	1 15	1 17	1 20	1 23	1 25	1 28	1 31	18 24
6 36	1 6	1 9	1 11	1 14	1 17	1 20	1 22	1 25	1 28	1 31	1 33	18 36
6 48	1 8	1 11	1 14	1 16	1 19	1 22	1 25	1 28	1 31	1 33	1 36	18 48
7 0	1 10	1 13	1 16	1 19	1 22	1 25	1 27	1 30	1 33	1 36	1 39	19 0
7 12	1 12	1 15	1 18	1 21	1 24	1 27	1 30	1 33	1 36	1 39	1 42	19 12
7 24	1 14	1 17	1 20	1 23	1 26	1 29	1 32	1 36	1 39	1 42	1 45	19 24
7 36	1 16	1 19	1 22	1 25	1 29	1 32	1 35	1 38	1 41	1 44	1 46	19 36
7 48	1 18	1 21	1 24	1 28	1 31	1 34	1 37	1 41	1 44	1 47	1 50	19 48
8 0	1 20	1 23	1 27	1 30	1 33	1 37	1 40	1 43	1 47	1 50	1 53	20 0
8 12	1 22	1 25	1 29	1 32	1 36	1 39	1 42	1 46	1 49	1 53	1 56	20 12
8 24	1 24	1 27	1 31	1 34	1 38	1 41	1 45	1 48	1 52	1 55	1 59	20 24
8 36	1 26	1 30	1 33	1 37	1 40	1 44	1 47	1 51	1 55	1 58	2 2	20 36
8 48	1 28	1 32	1 35	1 39	1 43	1 46	1 50	1 54	1 57	2 1	2 5	20 48
9 0	1 30	1 34	1 37	1 41	1 45	1 49	1 52	1 56	2 0	2 4	2 7	21 0
9 12	1 32	1 36	1 40	1 43	1 47	1 51	1 55	1 59	2 3	2 6	2 10	21 12
9 24	1 34	1 38	1 42	1 46	1 50	1 54	1 57	2 1	2 5	2 9	2 13	21 24
9 36	1 36	1 40	1 44	1 48	1 52	1 56	2 0	2 4	2 8	2 12	2 16	21 36
9 48	1 38	1 42	1 46	1 50	1 54	1 58	2 2	2 7	2 11	2 15	2 19	21 48
10 0	1 40	1 44	1 48	1 52	1 57	2 1	2 5	2 9	2 13	2 17	2 22	22 0
10 12	1 42	1 46	1 50	1 55	1 59	2 3	2 7	2 12	2 16	2 20	2 24	22 12
10 24	1 44	1 48	1 53	1 57	2 1	2 5	2 10	2 14	2 19	2 23	2 27	22 24
10 36	1 46	1 50	1 55	1 59	2 4	2 8	2 12	2 17	2 21	2 26	2 30	22 36
10 48	1 48	1 52	1 57	2 1	2 6	2 11	2 15	2 19	2 24	2 28	2 33	22 48
11 0	1 50	1 55	1 59	2 4	2 8	2 13	2 17	2 22	2 27	2 31	2 36	23 0
11 12	1 52	1 57	2 1	2 6	2 11	2 15	2 20	2 25	2 29	2 34	2 39	23 12
11 24	1 54	1 59	2 3	2 8	2 13	2 18	2 22	2 27	2 32	2 37	2 41	23 24
11 36	1 56	2 1	2 6	2 10	2 15	2 20	2 25	2 30	2 35	2 39	2 44	23 36
11 48	1 58	2 3	2 8	2 13	2 18	2 23	2 27	2 32	2 37	2 42	2 47	23 48
12 0	2 0	2 5	2 10	2 15	2 20	2 25	2 30	2 35	2 40	2 45	2 50	24 0

TABLE XXXI.

For reducing the Sun's Right Ascension in Time, as given in the Nautical Almanac for Noon at Greenwich, to any other time under any other Meridian.

Time from Noon.	Daily Variation of the Sun's Right Ascension in Time.																		Ship's Long.
	′	″	′	″	′	″	′	″	′	″	′	″	′	″	′	″	′	″	
	3	30	3	32	3	34	3	36	3	38	3	40	3	42	3	44	3	46	
0h 0′	0′	0″	0′	0″	0′	0″	0′	0″	0′	0″	0′	0″	0′	0″	0′	0″	0′	0″	0°
0 12	0	2	0	2	0	2	0	2	0	2	0	2	0	2	0	2	0	2	3
0 24	0	3	0	4	0	4	0	4	0	4	0	4	0	4	0	4	0	4	6
0 36	0	5	0	5	0	5	0	5	0	5	0	5	0	6	0	6	0	6	9
0 48	0	7	0	7	0	7	0	7	0	7	0	7	0	7	0	7	0	8	12
1 0	0	9	0	9	0	9	0	9	0	9	0	9	0	9	0	9	0	9	15
1 12	0	10	0	11	0	11	0	11	0	11	0	11	0	11	0	11	0	11	18
1 24	0	12	0	12	0	12	0	13	0	13	0	13	0	13	0	13	0	13	21
1 36	0	14	0	14	0	14	0	14	0	15	0	15	0	15	0	15	0	15	24
1 48	0	16	0	16	0	16	0	16	0	16	0	16	0	17	0	17	0	17	27
2 0	0	17	0	18	0	18	0	18	0	18	0	18	0	18	0	19	0	19	30
2 12	0	19	0	19	0	20	0	20	0	20	0	20	0	20	0	21	0	21	33
2 24	0	21	0	21	0	21	0	22	0	22	0	22	0	22	0	22	0	23	36
2 36	0	23	0	23	0	23	0	23	0	24	0	24	0	24	0	24	0	24	39
2 48	0	24	0	25	0	25	0	25	0	25	0	26	0	26	0	26	0	26	42
3 0	0	26	0	26	0	27	0	27	0	27	0	27	0	28	0	28	0	28	45
3 12	0	28	0	28	0	29	0	29	0	29	0	29	0	30	0	30	0	30	48
3 24	0	30	0	30	0	30	0	31	0	31	0	31	0	31	0	32	0	32	51
3 36	0	31	0	32	0	32	0	32	0	33	0	33	0	33	0	34	0	34	54
3 48	0	33	0	34	0	34	0	34	0	35	0	35	0	35	0	35	0	36	57
4 0	0	35	0	35	0	36	0	36	0	36	0	37	0	37	0	37	0	38	60
4 12	0	37	0	37	0	37	0	38	0	38	0	38	0	39	0	39	0	40	63
4 24	0	38	0	39	0	39	0	40	0	40	0	40	0	41	0	41	0	41	66
4 36	0	40	0	41	0	41	0	41	0	42	0	42	0	43	0	43	0	43	69
4 48	0	42	0	42	0	43	0	43	0	44	0	44	0	44	0	45	0	45	72
5 0	0	44	0	44	0	45	0	45	0	45	0	46	0	46	0	47	0	47	75
5 12	0	45	0	46	0	46	0	47	0	47	0	48	0	48	0	49	0	49	78
5 24	0	47	0	48	0	48	0	49	0	49	0	49	0	50	0	50	0	51	81
5 36	0	49	0	49	0	50	0	50	0	51	0	51	0	52	0	52	0	53	84
5 48	0	51	0	51	0	52	0	52	0	53	0	53	0	54	0	54	0	55	87
6 0	0	52	0	53	0	53	0	54	0	54	0	55	0	55	0	56	0	56	90
6 12	0	54	0	55	0	55	0	56	0	56	0	57	0	57	0	58	0	58	93
6 24	0	56	0	57	0	57	0	58	0	58	0	59	0	59	1	0	1	0	96
6 36	0	58	0	58	0	59	0	59	1	0	1	0	1	1	1	2	1	2	99
6 48	0	59	1	0	1	1	1	1	1	2	1	2	1	3	1	3	1	4	102
7 0	1	1	1	2	1	2	1	3	1	4	1	4	1	5	1	5	1	6	105
7 12	1	3	1	4	1	4	1	5	1	5	1	6	1	7	1	7	1	8	108
7 24	1	5	1	5	1	6	1	7	1	7	1	8	1	8	1	9	1	10	111
7 36	1	6	1	7	1	8	1	8	1	9	1	10	1	10	1	11	1	12	114
7 48	1	8	1	9	1	10	1	10	1	11	1	11	1	12	1	13	1	13	117
8 0	1	10	1	11	1	11	1	12	1	13	1	13	1	14	1	15	1	15	120
8 12	1	12	1	12	1	13	1	14	1	14	1	15	1	16	1	17	1	17	123
8 24	1	13	1	14	1	15	1	16	1	16	1	17	1	18	1	18	1	19	126
8 36	1	15	1	16	1	17	1	17	1	18	1	19	1	20	1	20	1	21	129
8 48	1	17	1	18	1	18	1	19	1	20	1	21	1	21	1	22	1	23	132
9 0	1	19	1	19	1	20	1	21	1	22	1	22	1	23	1	24	1	25	135
9 12	1	20	1	21	1	22	1	23	1	24	1	24	1	25	1	26	1	27	138
9 24	1	22	1	23	1	24	1	25	1	25	1	26	1	27	1	28	1	29	141
9 36	1	24	1	25	1	26	1	26	1	27	1	28	1	29	1	30	1	30	144
9 48	1	26	1	27	1	27	1	28	1	29	1	30	1	31	1	31	1	32	147
10 0	1	27	1	28	1	29	1	30	1	31	1	32	1	32	1	33	1	34	150
10 12	1	29	1	30	1	31	1	32	1	33	1	33	1	34	1	35	1	36	153
10 24	1	31	1	32	1	33	1	34	1	34	1	35	1	36	1	37	1	38	156
10 36	1	33	1	34	1	35	1	35	1	36	1	37	1	38	1	39	1	40	159
10 48	1	34	1	35	1	36	1	37	1	38	1	39	1	40	1	41	1	42	162
11 0	1	36	1	37	1	38	1	39	1	40	1	41	1	42	1	43	1	44	165
11 12	1	38	1	39	1	40	1	41	1	42	1	43	1	44	1	45	1	45	168
11 24	1	40	1	41	1	42	1	43	1	44	1	44	1	45	1	46	1	47	171
11 36	1	41	1	42	1	43	1	44	1	45	1	46	1	47	1	48	1	49	174
11 48	1	43	1	44	1	45	1	46	1	47	1	48	1	49	1	50	1	51	177
12 0	1	45	1	46	1	47	1	48	1	49	1	50	1	51	1	52	1	53	180
	3′	30″	3	32	3′	34″	3	36	3	38	3′	40	3	42	3	44	3	46	

For reducing the Sun's Right Ascension in Time, as given in the Nautical Almanac for Noon at Greenwich, to any other time under any other Meridian.

Time from Noon	Daily Variation of the Sun's Right Ascension in Time. ′ ″ 3 48	′ ″ 3 50	′ ″ 3 52	′ ″ 3 54	′ ″ 3 56	′ ″ 3 58	′ ″ 4 0	′ ″ 4 2	′ ″ 4 4	′ ″ 4 6	Ship's Long.
0h 0′	0′ 0″	0′ 0″	0′ 0″	0′ 0″	0′ 0″	0′ 0″	0′ 0″	0′ 0″	0′ 0″	0′ 0″	0
0 12	0 2	0 2	0 2	0 2	0 2	0 2	0 2	0 2	0 2	0 2	3
0 24	0 4	0 4	0 4	0 4	0 4	0 4	0 4	0 4	0 4	0 4	6
0 36	0 6	0 6	0 6	0 6	0 6	0 6	0 6	0 6	0 6	0 6	9
0 48	0 8	0 8	0 8	0 8	0 8	0 8	0 8	0 8	0 8	0 8	12
1 0	0 9	0 10	0 10	0 10	0 10	0 10	0 10	0 10	0 10	0 10	15
1 12	0 11	0 11	0 12	0 12	0 12	0 12	0 12	0 12	0 12	0 12	18
1 24	0 13	0 13	0 14	0 14	0 14	0 14	0 14	0 14	0 14	0 14	21
1 36	0 15	0 15	0 15	0 16	0 16	0 16	0 16	0 16	0 16	0 16	24
1 48	0 17	0 17	0 17	0 18	0 18	0 18	0 18	0 18	0 18	0 18	27
2 0	0 19	0 19	0 19	0 19	0 20	0 20	0 20	0 20	0 20	0 20	30
2 12	0 21	0 21	0 21	0 21	0 22	0 22	0 22	0 22	0 22	0 23	33
2 24	0 23	0 23	0 23	0 23	0 24	0 24	0 24	0 24	0 24	0 25	36
2 36	0 25	0 25	0 25	0 25	0 26	0 26	0 26	0 26	0 26	0 27	39
2 48	0 27	0 27	0 27	0 27	0 28	0 28	0 28	0 28	0 28	0 29	42
3 0	0 28	0 29	0 29	0 29	0 29	0 30	0 30	0 30	0 30	0 31	45
3 12	0 30	0 31	0 31	0 31	0 31	0 32	0 32	0 32	0 33	0 33	48
3 24	0 32	0 33	0 33	0 33	0 33	0 34	0 34	0 34	0 35	0 35	51
3 36	0 34	0 34	0 35	0 35	0 35	0 36	0 36	0 36	0 37	0 37	54
3 48	0 36	0 36	0 37	0 37	0 37	0 38	0 38	0 38	0 39	0 39	57
4 0	0 38	0 38	0 39	0 39	0 39	0 40	0 40	0 40	0 41	0 41	60
4 12	0 40	0 40	0 41	0 41	0 41	0 42	0 42	0 42	0 43	0 43	63
4 24	0 42	0 42	0 43	0 43	0 43	0 44	0 44	0 44	0 45	0 45	66
4 36	0 44	0 44	0 44	0 45	0 45	0 46	0 46	0 46	0 47	0 47	69
4 48	0 46	0 46	0 46	0 47	0 47	0 48	0 48	0 48	0 49	0 49	72
5 0	0 47	0 48	0 48	0 49	0 49	0 50	0 50	0 50	0 51	0 51	75
5 12	0 49	0 50	0 50	0 51	0 51	0 52	0 52	0 52	0 53	0 53	78
5 24	0 51	0 52	0 52	0 53	0 53	0 54	0 54	0 54	0 55	0 55	81
5 36	0 53	0 54	0 54	0 55	0 55	0 56	0 56	0 56	0 57	0 57	84
5 48	0 55	0 56	0 56	0 57	0 57	0 58	0 58	0 58	0 59	0 59	87
6 0	0 57	0 57	0 58	0 58	0 59	0 59	1 0	1 0	1 1	1 1	90
6 12	0 59	0 59	1 0	1 0	1 1	1 1	1 2	1 3	1 3	1 4	93
6 24	1 1	1 1	1 2	1 2	1 3	1 3	1 4	1 5	1 5	1 6	96
6 36	1 3	1 3	1 4	1 4	1 5	1 5	1 6	1 7	1 7	1 8	99
6 48	1 5	1 5	1 6	1 6	1 7	1 7	1 8	1 9	1 9	1 10	102
7 0	1 6	1 7	1 8	1 8	1 9	1 9	1 10	1 11	1 11	1 12	105
7 12	1 8	1 9	1 10	1 10	1 11	1 11	1 12	1 13	1 13	1 14	108
7 24	1 10	1 11	1 12	1 12	1 13	1 13	1 14	1 15	1 15	1 16	111
7 36	1 12	1 13	1 13	1 14	1 15	1 15	1 16	1 17	1 17	1 18	114
7 48	1 14	1 15	1 15	1 16	1 17	1 17	1 18	1 19	1 19	1 20	117
8 0	1 16	1 17	1 17	1 18	1 19	1 19	1 20	1 21	1 21	1 22	120
8 12	1 18	1 19	1 19	1 20	1 21	1 21	1 22	1 23	1 23	1 24	123
8 24	1 20	1 20	1 21	1 22	1 23	1 23	1 24	1 25	1 25	1 26	126
8 36	1 22	1 22	1 23	1 24	1 25	1 25	1 26	1 27	1 27	1 28	129
8 48	1 24	1 24	1 25	1 26	1 27	1 27	1 28	1 29	1 29	1 30	132
9 0	1 25	1 26	1 27	1 28	1 28	1 29	1 30	1 31	1 31	1 32	135
9 12	1 27	1 28	1 29	1 30	1 30	1 31	1 32	1 33	1 34	1 34	138
9 24	1 29	1 30	1 31	1 32	1 32	1 33	1 34	1 35	1 36	1 36	141
9 36	1 31	1 32	1 33	1 34	1 34	1 35	1 36	1 37	1 38	1 38	144
9 48	1 33	1 34	1 35	1 36	1 36	1 37	1 38	1 39	1 40	1 40	147
10 0	1 35	1 36	1 37	1 37	1 38	1 39	1 40	1 41	1 42	1 42	150
10 12	1 37	1 38	1 39	1 39	1 40	1 41	1 42	1 43	1 44	1 45	153
10 24	1 39	1 40	1 41	1 41	1 42	1 43	1 44	1 45	1 46	1 47	156
10 36	1 41	1 42	1 42	1 43	1 44	1 45	1 46	1 47	1 48	1 49	159
10 48	1 43	1 43	1 44	1 45	1 46	1 47	1 48	1 49	1 50	1 51	162
11 0	1 44	1 45	1 46	1 47	1 48	1 49	1 50	1 51	1 52	1 53	165
11 12	1 46	1 47	1 48	1 49	1 50	1 51	1 52	1 53	1 54	1 55	168
11 24	1 48	1 49	1 50	1 51	1 52	1 53	1 54	1 55	1 56	1 57	171
11 36	1 50	1 51	1 52	1 53	1 54	1 55	1 56	1 57	1 58	1 59	174
11 48	1 52	1 53	1 54	1 55	1 56	1 57	1 58	1 59	2 0	2 1	177
12 0	1 54	1 55	1 56	1 57	1 58	1 59	2 0	2 1	2 2	2 3	180
	3′ 48″	3′ 50″	3′ 52″	3′ 54″	3′ 56″	3′ 58″	4′ 0″	4′ 2″	4′ 4″	4′ 6″	

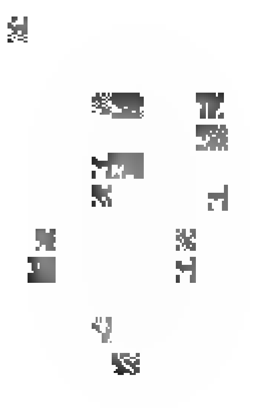

TABLE XLV.

Equation of Second Differences to be applied to the *mean* longitude or latitude with a sign *contrary* to that of the mean of the second differences.

Ap. time after noon or midnight.		Second Difference.											
		1′	2′	3′	4′	5′	6′	7′	8′	9′	10′	11′	12′
h m	h m	″	″	″	″	″	″	″	″	″	″	″	″
0. 0	12. 0	0 0	0.0	0.0	0 0	0.0	0.0	0.0	0 0	0.0	0.0	0.0	0.0
0.10	11.50	0.4	0.8	1.2	1.6	2.1	2 5	2.9	3.3	3.7	4.1	4.5	4.9
0.20	11.40	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
0.30	11.30												
0.40	11 20												
0.50	11.10												
1. 0	11. 0												
1.10	10 50												
1.20	10.40												
1.30	10.30												
1.40	10.20												
1 50	10 10												
2. 0	10 0												
2.10	9.50												
2.20	9.40												
2.30	9.30												
2.40	9 20												
2.50	9 10												
3. 0	9 0												
3.10	8 50												
3.20	8.40												
3.30	8.30												
3.40	8.20												
3.50	8.10												
4. 0	8. 0												
4.20	7.40												
4.40	7.20												
5. 0	7. 0												
5.20	6.40												
5.40	6.20												
6. 0	6 0												
Ap. time after noon													

1. 0	11. 0
1.10	10.50
1.20	10.40
1.30	10.30
1.40	10.20
1.50	10.10
2. 0	10. 0
2 10	9.50
2.20	9.40
2.30	9.30
2.40	9.20
2.50	9.10
3. 0	9. 0
3.10	8.50
3.20	8 40
3.30	8.30
3.40	8.20
3.50	8 10
4. 0	8. 0
4.20	7.40
4.40	7.20
5. 0	7. 0
6. 0	6 0

		Lat. D. M.	Long. D. M.
Louisiana.	Key Broton	29 28N	89 18W
	Entrance of MISSISSIPPI, N. E. . .	29 12	89 09
	La Balisa . . .	29 08	89 06
	— S. E	28 59	89 13
	— S. W.	28 56	89 29
	NEW-ORLEANS . .	29 57	90 09
	Baton Rouge . . .	30 36	91 13
	Long-Island . . .	29 15	90 14
	I. Toubalie, S. P. . .	28 52	90 49
	I. del Vino W. end . .	28 56	91 24
	Bancos de Hostiones, — S. P.	28 50	91 44
	— W. P.	29 26	93 04
	Iron Point or Point Pierre	29 14	92 07
	Deer Point	29 26	92 29
	Point del Pajaro .	29 24	92 43
	River Lobos, ent. . .	29 32	93 04
	Salt Water Bay . . .	29 26	93 28
	Constant Bay . . .	29 27	93 39
	River Mermentao . .	29 38	94 11
	Point ent. river Sabine	29 10	94 57

II. *Islands in the West Indies*

		Lat. D. M.	Long. D. M.
Windward Islands.	TRINIDAD,		
	— Spanish Town . .	10 39N.	61 30W
	— Icaque Point . .	10 04	61 55
	— Point Galiote . .	10 09	60 55
	— Point Galera . .	10 51	60 51
	Tobago, N. E. point .	11 29	60 17
	S. W. point . .	11 05	60 48
	Grenada, N. E. point .	12 19	61 40
	— S. W. do. . . .	11 58	61 52
	middle	11 55	62 16
	Barbadoes, S. P. . .	13 01	59 36
	— E. do. . . .	13 08	59 24
	— Bridgetown . .	13 05	59 41
	— N. W. point . .	13 18	59 44
	St. Vincents, N. point .	13 12	61 24
	S. do. . . .	13 01	61 20
	St. Lucia, S. point. .	13 30	61 00
	— N. do.	14 56	60 56
	Martinico, S. E. point .	14 24	60 56
	— Diamond Rock .	14 24	61 06
	— Port Royal . .	14 36	61 09
	— Macouba Point .	14 56	61 20
	Dominica, S. point. .	15 14	61 20
	N. do.	15 39	61 30
	The Saints Island . .	15 52	61 37
	Mariagalante, N. P. .	16 04	61 14
	S. do.	15 53	61 15
	Guadaloupe, S. W. P. .	15 57	61 48
	— N. W. do. . . .	16 20	61 56
	— N. E. do. . . .	16 30	61 32
	S. E. do. . . .	16 11	61 15
	Desenda	16 21	61 09
	Antigua, E. P. . . .	17 05	61 44
	— W. point . .	17 05	62 00
	Monserrat, S. P. . .	16 12	62 17
	— N. P. . . .	16 50	62 17
	Redondo Island . .	16 56	62 22
	Nevis	17 09	62 33
	St. Christ'rs or St. Kitts — S. E. point . . .	17 12	62 30

		Lat. D. M.	Long. D. M.
Windward Islands.	St. Christ'rs or St. Kitts — N. W. point . .	17 24N	62 51W
	St. Eustatia Town . .	17 29	63 02
	Saba	17 40	63 16
	Aves or Bird's I. about	15 40	63 40
	Barbuda, N. P. . . .	17 44	61 50
	St. Bartholomew, E.P.	17 54	62 40
	St. Martin's, E. P. . .	18 04	63 01
	Anguila, S.W. point .	18 12	63 09
	— N. E. do. . .	18 16	62 52
	Prickly Pear . . .	18 20	63 15
	Isle of Dogs, western .	18 19	63 20
	Sombrero	18 30	63 30
Virgin Islands.	St. Croix or St. Cruz E. P.	17 45	64 34
	— W. P.	17 42	64 54
	Anegada S. P. of shoal	18 35	64 09
	W. P. . . .	18 46	64 23
	Virgin Gorda, E. P. .	18 30	64 18
	Tortola, E. P. . . .	18 28	64 31
	— W. P.	18 25	64 42
	St. John's	18 22	64 42
	St. Thomas . . .	18 22	64 55
	Bird Key	18 15	64 50
	Serpent I. E. part .	18 19	65 17
	Crab I. E. part .	18 10	65 15
Porto Rico.	Cape St. John or N. E	18 24	65 35
	PORTO RICO . . .	18 29	66 05
	Point Brugnen or N. W	18 31	67 07
	Point St. Francisco	18 22	67 13
	Cape Roxo or S. W. P.	17 50	67 09
	Los Morillos . .	18 00	67 16
	Point Coamo . . .	17 53	66 27
	C. Mala Pasqua or S.E.P	17 59	65 47
	Shoal	19 20	65 50
	Muertos Island . . .	17 52	66 30
	La Mona I. . . .	18 06	67 50
	Monito I	18 09	67 53
	Zacheo or Desecheo I	18 24	67 26
Hispaniola.	Cape Engano . . .	18 35	68 20
	Saona I. E. part .	18 13	68 31
	St. Catherine's I. .	18 18	68 58
	St. Domingo . . .	18 28	69 51
	La Catalina . . .	18 09	70 11
	Cape Beata	17 42	71 20
	Altavela rock off do.	17 28	71 21
	Cape Jacquemel . .	18 13	72 35
	Island Bacu . . .	18 04	73 30
	Point Gravois . . .	18 00	73 55
	Cape Tiburon . . .	18 20	74 29
	Navaza Island . . .	18 24	75 03
St. Domingo.	Cape Donna Maria	18 38	74 27
	Jeremy	18 38	74 07
	Cayemite	18 39	73 43
	Petit Guave . . .	18 25	72 54
	Leogane	18 29	72 28
	PORT-AU-PRINCE .	18 33	72 21
	I. Gonave, S. E. P. .	18 42	72 47
	— N. W. P. . . .	18 56	73 18
	St. Mark	19 04	72 45
	St. Nichola Mole .	19 49	73 25
	Tortudas W. P. .	20 06	72 54
	— E. P.	20 02	72 46
	CAPE FRANCOIS	19 45	72 18

		Lat. D. M.	Long. D. M.
Turkey in Asia.	Cape Black	38 46N.	26 25E.
	SMYRNA	38 28	27 20
	Adramitta	39 37	27 05
	Cape Baba	39 35	26 10
	Cape Janesari	40 03	26 21
	Mondania	40 26	28 50
	Scutari	40 57	29 04

XXXII. *Islands within the Straits.*

		Lat. D. M.	Long. D. M.
	Alboran	36 01N.	3 00W
	Fromentera, W. point	38 39	0 57E.
	— E ditto	38 43	1 24
	Ivica, S. ditto	38 50	0 55
	— N. E. ditto	39 15	1 25
	Salina	38 49	0 50
	Cabrera, S. point	39 12	2 37
Majorca.	MAJORCA, S. point	39 20	2 42
	— N. ditto	40 07	3 00
	— W. ditto	39 45	2 07
	— E. ditto	39 42	3 17
	— MAJORCA TOWN	39 34	2 39
	Dragon Island	39 49	1 59
	Colebres	39 52	0 30
	Minorca, S. point	39 43	3 42
	— PORT MAHON	39 52	4 22
	— N. point	40 13	3 55
Corsica.	Cape Corse	43 02	9 19
	Saint Florenzo	42 35	9 16
	Calvi	42 30	8 40
	Ajacio	41 52	8 44
	South point	41 21	9 21
	Cape Signo	42 14	9 37
	BASTIA	42 27	9 32
Sardinia.	N. P. Lagosardo	41 14	9 02
	Cape Asinara	40 53	8 06
	Cape Caccia	40 31	8 07
	Cape Otano	39 09	8 14
	Cape Malfetena	38 50	8 54
	CAGLIARI	39 15	9 30
	Cape Carbonera	38 57	9 43
	Cape Frances	39 59	9 50
	Olaster	40 03	9 34
	Cape Cavallo	40 43	9 47
	Asinara Isl. N. point	41 07	8 14
	Antioch Island	[illegible]	8 15
	Toro	38 47	8 12
	Galita Island	37 33	9 03
	Gorgona	43 25	9 51
	Cabrera	[illegible] 03	9 53
	Elba	42 50	10 12
	Planera	42 43	10 07
	Formigues	42 33	10 05
	Monte Christo	42 17	10 25
	Gilio	42 22	11 00
	Ganuto	42 16	11 10
	Palmaria	40 45	13 [illegible]
	Fosca	40 42	13 [illegible]
	Ischia, S. point	40 38	13 [illegible]

		Lat. D. M.	Long. D. M.
	Capra	40 31N	14 18E.
Sicily.	MESSINA	38 14	15 49
	Cape Orlando	38 20	14 40
	Cape Cefala	38 15	14 05
	Cape Cafrana	38 18	13 36
	PALERMO	38 07	13 20
	Cape Alos	38 18	13 23
	Cape St. Visto	38 17	12 50
	Tripano	38 09	12 36
	Cape Ruso	37 17	13 20
	Cape Alicate	37 03	13 50
	Cape Secha	36 49	14 26
	Cape Passari	36 41	15 32
	Saragossa	37 05	15 30
	Cape Carnale	37 24	15 39
	Cape Moline	37 37	15 43
	Stromboli	38 56	15 44
	Lipari, S. point	38 37	15 07
	Salini	38 44	14 55
	Volcano	38 32	15 07
	Felicudi	38 35	14 27
	Alicudi	38 36	14 12
	Ustica	38 51	13 20
	Levaci	38 05	12 25
	Maretimo	38 01	12 05
	Favognana	37 56	12 23
	Quill Rocks	37 35	11 15
	Pantellaria	36 45	12 31
	Linosa	35 52	12 55
	La Pidosa	35 31	12 47
	Lampion	35 30	12 30
Malta.	Gozo, N. point	36 03	14 05
	C. Comoneto	35 54	14 11
	La Valette	35 54	14 29
	Cape Nicholas	35 47	14 39
Gulf of Venice.	Fano, entrance to the gulf of Venice	40 05	19 32
	Pelagosa	42 23	16 20
	Piana	42 20	16 03
	Tremiti	42 19	15 40
	Lissa, S. point	42 37	16 15
	Pomo	43 13	15 46
	Longa, S. E. point	44 01	15 43
	Corfu, S. E. point	39 47	20 07
	Paxu, S. point	39 24	20 22
	St. Maura, W. point	38 54	20 41
	Cefalonia, S. point	38 07	20 53
	— Cape Viscardo	38 30	20 47
	Zante, S. point	37 30	20 49
Archipelago.	Cerigo, S. point	36 20	23 01
	Cerigotto	35 54	23 24
	Milo, Town	36 41	24 50
	Scio, Town	38 30	26 03
	Mytelene, Town	39 12	26 27
	Tenedos	39 50	26 06
	Lemnos	39 54	25 23
Candia.	C. C[illegible]	35 12	23 39
	Cape Spada	35 47	23 57
	Suda	35 30	24 24
	Cape S[illegible]	35 35	25 07
	CANDIA	35 19	25 18

ADDITIONS AND CORRECTIONS, TABLE XLVI.

Page 257	Col. 1.	*for*	P. Carachine	*read*	P. Garachine.
	Col. 2.	*for*	Montery	*read*	Monterey.
263	Col. 2.	*for*	Walcheron	*read*	Walcheren.
ditto.		*for*	Gottengen	*read*	Gottingen.
264	Col. 2.	*for*	10° 50′	*read*	10° 50′ E.
273	Col. 1.	*for*	Point de Gulle	*read*	Point de Galle.
274	Col. 1.	*for*	*L*alangare	*read*	Salangore.
275	Col. 2.	*for*	Ker*q*uellan's	*read*	Kerguellan's.
ditto.		*for*	12f. 14f.	*read*	12 fathoms, 14 fathoms.
276	Col. 2.	*for*	Coetio*g*	*read*	Coetivy.
ditto.		*for*	Collomand*ola's*	*read*	Collomandous.
ditto.		*for*	*N'M*andous	*read*	*Nill*mandous.
277	top.	*for*	Se*w*elli	*read*	Seuvelli.
277	Col. 1.	The longitude of Flat Rock is 93° 40′.			
	Col. 2.	*for*	Billi*ng*bing	*read*	Billimbing.
278	Col. 1.	*for*	Sed*u*ry	*read*	Sedary.
ditto.		*for*	*L*amarang	*read*	Samarang.
	Col. 2.	*for*	Armuyde*r*	*read*	Armuyden.

Ditto. I have considered the *Essex Shoal* to be the same as the *Fairlie Rock*, and have given its latitude and longitude as in Horsburgh's Directory, namely 3° 27′ S. 107° 02′ E. The place assigned by Captain Orne of the Essex is 3° 36′ S. 107° 00′ E. differing 9 miles in latitude; and as it is possible that the rocks may not be the same, I have now given Captain Orne's estimate made from a meridian observation two hours after *striking* on the shoal, June 26, 1804. He described it as a small rock or coral *patch*, seen by the man at the mast-head an instant before she struck, but there was no appearance of a *breaker*, though the breeze was fresh, and a short sea running. In the act of *wearing* ship, she struck rather on the side of the rock, which reduced her velocity from 8 to 2½ knots, after rubbing a few seconds, she fell off into deeper water (8 fathoms) without any meterial damage.

Page 279	Col. 1.	*for*	Toekoekemo*n*	*read*	Toekoekemou.
		for	Cari*n*iata	*read*	Carimata.
	Col. 2.	*for*	Pulo Batta*in*	*read*	Pulo Battam.
		for	D*e*nding	*read*	Dinding.
		for	*L*angald	*read*	Sangald.
		for	Tambela*r*is	*read*	Tambelan's.
280	Col. 2.	*for*	Asse*ol*ido	*read*	Asseveido.
ditto line 39.		*for*	last article	*read*	No. 46.

NEW SOUTH SHETLAND.

The following latitudes and longitudes of places in New South Shetland have been procured, from different sources, since the printing of the first part of this Table. It contains the best (though very imperfect) account that could be procured at the time of the publication of this work. The person who gave the observations marked*, observed, that the latitudes of those places was very near the truth, but there might be some uncertainty in the longitudes; the same remark may probably apply to all of them.

	Lat. D. M.	Long. D. M.
Clarence Island, Floyd's Promontory . .	60 57S.	54 06W
——— Cape Bowles	61 20	54 08
Cornwallis Island	61 00	54 28
Seal Islands	61 00	55 32
Cape Valentine	61 03	54 40
Sarah Island*	61 22	55 30
Obrien's Islands	61 28	56 35
Bridgeman's Islands	62 00	57 12
Cape Melville	62 00	57 46
Sheriff Cape	62 28	60 57
Ditto (another account)* . . .	62 21	61 47
Yankee Straits*	62 30	60 22
Ragged Island	62 40	62 10
Ditto (another account)*	62 42	62 20
Ditto the harbour (by another person) .	62 55	63 05
New Plymouth	62 45	61 37
Monroe's Island, President's Bay . . .	62 46	62 20
Castle Rock (west of Monroe's I.) . . .	62 50	62 30
Mount Pisgah	63 00	63 00
Ditto (another account)*	62 57	63 40

APPENDIX,

CONTAINING METHODS OF DETERMINING THE LONGITUDE BY OBSERVATIONS OF ECLIPSES, OCCULTATIONS, &c.

THE longitude of a place may be determined in a very accurate manner, by observing the beginning or end of a solar eclipse, or occultation of a fixed star by the moon, or the difference between the times that the moon and a known fixed star pass the meridian. These observations when made on land with a good telescope and well regulated time-keeper, furnish by far the most accurate method of determining the longitude, and when made on board a ship without a telescope, will in general give it to a greater degree of accuracy than any other method. For this reason, it was thought proper to insert in this Appendix the usual rules of calculating such observations, by means of the Nautical Almanac. The first thing to be taken notice of, is the method of determining the longitude, latitude, &c. of the moon or other object, having regard to the unequal velocity between the times for which these quantities are given in the Nautical Almanac. This calculation is rendered much more simple by making use of the signs + and —, and performing addition and subtraction as in the introductory rules of Algebra; and as it is possible that these rules may not be familiar to some readers of this work, it was thought proper to prefix an explanation, as far as will be necessary in the present problems.

Quantities *without a sign* or with the sign + prefixed are called *positive* or *affirmative*, as 7 or + 7; and those to which the sign — is prefixed are called *negative*, as — 7. *Addition of quantities having the same sign, that is, all affirmative or all negative, is performed by adding them as in common arithmetic, and prefixing the common sign.* Thus the sum of + 4 and + 3 is + 7. The sum of — 4, — 3 and — 5 is — 12. *When the quantities have not the same sign, the positive quantities must be added into one sum, and the negative into another, as above; the difference of these two sums, with the sign of the greater sum prefixed, will be the sum of the proposed quantities.* Thus the sum of + 14, — 7, + 5, and — 2, is found by adding + 14 and + 5, whose sum is + 19; and then — 7 and — 2, whose sum is — 9; the difference of 19 and 9 is 10, to which must be prefixed the sign of the greater number 19, which is +, so that the sought sum is + 10. The following examples will illustrate these rules.

Add +4	Add +4′ 10″	Add —4′ 10″	Add —4′ 10″	Add +1	Add +6′ 0″
+3	+2 5	—2 5	+2 5	—1	—2 15
+7					+4 13
—2	Sum +6 15	Sum —6 15	Sum —2 5	Sum 0	—3 7
Sum +12					Sum +4 51

Subtraction is performed by changing the sign of the number to be subtracted from + to —, or from — to +; and then adding the numbers by the preceding rule. Thus to subtract + 3 from + 7 the sign of + 3 must be changed, and the numbers — 3 and + 7 added together as in algebra, which by the preceding rule gives + 4; and if it were required to subtract — 3 from 7, the sign of — 3 must be changed, and + 3, + 7 added together. The sum + 10 represents the sought difference. It is not usual to make an actual change of the sign in any proposed question, it being sufficient to suppose the number to be subtracted to have a different sign from that prefixed to it, and to perform the operation accordingly. To illustrate this, the following examples are added.

Fro. +4′ 10″	Fro. +4′ 10″	Fro. —4′ 10″	Fro. —4′ 10″	Fro. +1	Fro. —1	Fro. +1
Sub. +2 5	Sub. —2 5	Sub. —2 5	Sub. +2 5	Sub. —1	Sub. —1	Sub. +1
Re. +2 5	Re. +6 15	Re. —2 5	Re. —6 15	Re. +2	Re. 0	Re. 0

From 108	From —108	From 108	From —108	From —201
Sub. 201	Sub. —201	Sub. —201	Sub. 201	Sub. 108
Rem. —93	Rem. +93	Rem +309	Rem. —309	Rem. —309

Observing that when no sign is annexed to a quantity the sign + is always understood to be prefixed.

PROBLEM I.

To find the longitude, latitude, &c. of the moon at any given time at Greenwich, having regard to the unequal velocity between the times marked in the Nautical Almanac. The intervals of these times being 12 hours.

RULE.

Take from the Nautical Almanac the two longitudes, latitudes, &c. next preceding the given time at Greenwich, and the two immediately following it, and set them down in succession below each other, prefixing the sign + to the southern latitudes or declinations, and the sign — to the northern. Subtract each of these quantities from the following for the *first differences*, and call the middle term arch A; subtract-

The time of the ecliptic conjunction, as given in the Nautical Almanac, is e computed from the geocentric longitudes of the objects; and as it may sometim required to seconds, the rule is here inserted, adapted to the calculation of the junction of the sun and moon; which, with a slight modification, will answer fo of the planets.

RULE.

Take from the Nautical Almanac the two longitudes of the sun and moon a noon and midnight* preceding the time of the conjunction and the two immedi following. Subtract the longitudes of the sun from those of the moon, notin signs as in algebra, the remainders will represent the *distances* of the sun from moon on the ecliptic. Subtract each of these from the following to obtain the *differences*, and call the middle term the arch A, subtract each of these differe from the following for the *second differences*, and take their half sum or mean fo arch B, noting the signs as in algebra.

To the constant logarithm 4.63548 add the arithmetical complement of the lo the arch A in seconds, and the log. of the second of the above found distances in conds, the sum rejecting 10 in the index will be the logarithm of the approximate lue of T in seconds.

With this time T at the side of Table XLV. and the arch B at the top find the e tion of second differences, the logarithm of which added to the two first logarit used in finding T, will, in rejecting 10 in the index, give the logarithm of the co tion of the approximate time T in seconds, to be applied to it with the *same sign the arch B*, and the apparent time of the conjunction at Greenwich, counted the second noon or midnight, taken from the Nautical Almanac, will be obtai From which the time of conjunction under any other meridian may be easily tained by adding to it the longitude in time when *east* or subtracting when *west*.

REMARK I. When the time of the ecliptic conjunction of the moon and a pl is required, the longitudes of the planet must be found by Problem I. for the and midnight immediately preceding, and those immediately following the tim the conjunction, and these are to be used in the above note instead of the sun's gitudes. If the ecliptic conjunction of the moon with a fixed star is required, its gitude must be found in Table XXXVII. and corrected for the equation of the e noxes and aberration by Tables XL. XLI. as shown in the explanation of those bles. This longitude is to be used instead of the sun's in the above rule.

REMARK 2. By the same rule the time, when the moon is at any distance f the sun, may be found, by increasing the sun's longitudes given in the N. A. by quantity the moon is supposed to be distant from the sun, counted according to order of the signs. Then supposing a *fictious* sun to move so as to have these creased longitudes at the corresponding times, and finding by the above rule the t of conjunction of the moon with this *fictious* sun, which will be the sought time w the moon is at the proposed distance from the sun. Thus to find the time of the f second, or third quarter of the moon, the sun's longitudes must be increased 3, 6 9 signs respectively (rejecting as usual 12 signs when the sun exceeds that quanti Thus if the first quarter of the moon which happened after midnight July 29, 18 was required. The sun's longitudes increased by 3 signs give the longitudes of *fictious* sun July 29d. 0h; 29d. 12h; 30d. 0h; and 30d. 12h. respectively, 7s. 6° 5' 7s. 6° 34' 26", 7s. 7° 3' 9", and 7s. 7° 31' 51". The longitudes of the moon corr ponding are 6s. 23° 49' 19", 7s. 0° 53' 34", 7s. 7° 57' 30", and 7s. 15° 0' 57". He the time of the conjunction of the moon with the *fictious* sun found by the above ru was July 29d. 22h. 21' at Greenwich; which is the time of the first quarter requir In a similar manner, by increasing the longitudes of a planet or a star, the time m be found when the moon is at any proposed distance from it.

EXAMPLE.

Required the time of the ecliptic conjunction of the sun and moon in Jan. 180

1808, Jan.		☽ Long.				☉ Long.				Distances.			1st. diff.				2d. diff.
		s.	°	'	"	s.	°	'	"	°	'	"		°	'	"	'
26d.	12h.	9	27	56	49	10	5	57	29	−8	0	40					
27	0	10	4	25	2	10	6	27	56	−2	2	54		+5	57	46	−3
27	12	10	10	50	3	10	6	58	26	+3	51	37	A=	+5	54	31	−3
28	0	10	17	11	41	10	7	28	55	+9	42	46		+5	51	09	B=−3

			Constant	4.63548	....	4.63
A	5° 54' 31" = 21271		log. co. ar.	5.67221	....	5.67
2 dis.	2 2 54 = 7374		log.	3.86770	Tab. XLV. Cor. 23".4 log.	1.3
T	14978"	= 4h. 9'. 38"		4.17539	Correction 45" log.	1.65
Correction		−45.				

Conjunction 4 8 51 past noon Jan. 27, at Greenwich, apparent time, wh agrees nearly with 4h. 9'. marked in the Nautical Almanac. The time of conju

* The sun's longitude at midnight is the mean of the longitudes on the preceding and following noo

tion under any other meridian, as for example 30° W. is found by subtracting the longitude 2h. from 4h. 8′ 51″, which leaves 2h. 8′ 51″. If the longitude had been 30° E. the time of conjunction would have been 6h. 8′ 51″.

The usual method of calculating the parallaxes in eclipses of the sun or occultations, is that by the *nonagesimal* or ninetieth degree of the ecliptic above the horizon. Several methods have been proposed for calculating the altitudes and longitudes of this point, which are required at each of the phases. The following, which is an improvement on that given in La Lande's Astronomy, seems well adapted to the purpose, since several of the logarithms are the same at each of the phases, which much abridges the calculation, and on this account it admits of considerable simplification, by a table like that on page 562. The method of making these calculations will first be given at full length, and then in the abridged form by means of the proposed table.

PROBLEM IV.

Given the apparent time at the place of observation counted from noon to noon, according to the manner of astronomers, the sun's right ascension, and the latitude of the place, reduced on account of the spheroidal figure of the earth by subtracting the reduction of latitude Table XXXVIII. To find the altitude and longitude of the nonagesimal degree of the ecliptic.

RULE NOT ABRIDGED.

Add 6 hours to the sum of the sun's right ascension and the apparent time of observation, and call the sum the time T, rejecting 24 hours when it exceeds that quantity. Seek for this time in the column of hours of Table XXVII. supposing that marked A. M. to be increased by 12 hours, as in the astronomical computation. The corresponding log. co-tangent being found, is to be marked in the first and second columns, as in the following examples.

If the reduced latitude is *north*, subtract it from 90°, if *south*, add it to 90°, the sum or difference will be the polar distance. Take half of this, and half the obliquity of the ecliptic, and find their *difference* and *sum*. Place the log. co-sine of the difference in the first column, its log. sine in the second column. The log. secant of the *sum* in the first column, its log. co-secant in the second column, and its log. tangent in the third.

The sum of the logarithms in the first column, rejecting 20 in the index, will be the log. tangent of the arch G. The sum of these in the second column, rejecting 20 in the index, will be the log. tangent of the arch F. These arches being *less* than 90° when the time T is found in the column A. M. otherwise *greater*. This rule is general except in places situated within the polar circles. Within the *north* polar circle the supplement of F to 360° instead of F must be taken; within the *south* polar circle the supplement of G to 180° must be taken instead of G, the other terms remaining unaltered. In all cases the longitude of the nonagesimal is equal to the sum of the arches F, G thus found, and 90°. Rejecting 360° when the sum exceeds that quantity.

Place in the third column the log. co-sine of G, and the log. secant of F, the sum of the three logarithms of this column, rejecting 20 in the index, will be the log. tangent of half the altitude of the Nonagesimal.

EXAMPLE.

Required the altitude and longitude of the Nonagesimal at Salem, in the reduced latitude 42° 22′ 4″ N. June 15, 1806, at 22h. 6′ 18″.1 apparent time by astronomical computation, when by the Nautical Almanac the sun's right ascension was 5h. 36′ 50″, and the obliquity of the ecliptic 23° 27′ 48″.

The sum of the apparent time, sun's right ascension and 6 hours, rejecting 24 hours, is 9h. 43′ 8″.1=T. The polar distance is 47° 37′ 56″, its half is 23° 48′ 58″, and the half obliquity 11° 43′ 54″, hence their difference is 12° 5′ 4″, their sum 35° 32′ 52″. The rest of the calculation is as follows:

		Col. I.		Col. 2.			Col. 3.
Diff.	12° 5′ 4″ Co-sine	9.99027	Sine	9.32038		Tangent	9.85403
Sum	35 32 52 Sec.	10.08957	Co-secant	10.23554	G.	Co-sine	9.97215
T.	9h. 43′ 8″.1 P. M. cot.	9.48826		9.48826	F.	Secant	10.00265
G.	159° 42′ 0″ Tan.	9.56810	F. Tan.	9.04468	33° 59′ 25″=Tan.		9.82883
F.	173 40 31						
	90				67 53 50 =Alt. Nonag.		
Sum	63 22 31 rejecting 360°, is longitude Nonages.						

The two upper logarithms of the first and second columns, and the upper logarithm of the third column, vary but little in several centuries; and as these numbers occur

twice in calculating a partial eclipse or occultation, and four times in a tota
annular eclipse or transit, it will tend considerably to abridge the calculatio
have a table like the following, containing their values for various places, fo
obliquity 23° 27′ 40″, with the variations for an increase of 100″ in the latitu
obliquity. The logarithms A, B, C, of the table were calculated in the follo
manner.

In *north* latitudes subtract the reduced latitude from 90°, in *south* latitudes
the reduced latitude to 90°, the sum or difference will be the polar distance;
half of this and half of the obliquity of the ecliptic 11° 43′ 50″, and find the
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Tab	[illegible]	[illegible]	[illegible]
Var. for + 8″ Obl.	+ 8	— 58	+
Sought values	A=0.079840	B=9.476579	C=9.854

Abridged method of calculating the altitude and longitude of the Nonagesimal, by the preceding Table.

Add together the sun's right ascension, the apparent time at the place of observation, (counted from noon to noon) and 6 hours, the sum, rejecting 24 or 48 hours if greater than those quantities, is to be called the time T; this is to be sought for in the column of hours of Table XXVII. supposing the column marked A. M. to be increased 12 hours, as in the astronomical computation.* The corresponding log. co-tangent, added to the log. A of the Table, gives the log. tangent of the arch G; this added to the log. B of the Table, rejecting 10 in the index, will be the log. tangent of the arch F; these arches being *less* than 90° when T is found in the column A. M. otherwise *greater*.† This rule is general, except in places situated within the polar circles, which is a case that very rarely occurs. Within the *north* polar circle, the supplement of F to 360° is to be used instead of F; within the *south* polar circle, the supplement of G to 180°, is to be taken instead of G, the other terms remaining unaltered. Then the *longitude of the Nonagesimal* is equal to the sum of the arches F, G, and 90°; neglecting as usual 360° when the sum exceeds that quantity.

To the tabular log. C, add the log. co-sine of the arch G, and the log. secant of the arch F, the sum, rejecting 20 in the index, will be the log. tangent of half the altitude of the Nonagesimal.‡

EXAMPLE I.

Required the altitudes and longitudes of the Nonagesimal at Salem, June 16, 1806, at the times of the beginning and end of the eclipse, calculated in Problem VI.?

Beginning of the Eclipse.

	h ' "				
	5 36 50.0	☉ R. Ascension			
	22 6 13.1	Apparent time			
	6	A	0.07384		
T	9 43 5.1	Co-tan.	9.48826		
G	159° 42' 0"	Tan.	9.568[illegible]0	Co-s.	9.97215
	90	B.	9.47653	C	9.55401
F	173 40 31	Tan.	9.04[illegible]	Sec.	10.00265
	61 22 31 = lon. N.	33 53 25		Tan.	9.[illegible]53
Altitude Nonages.		67 5[illegible] 50			

End of the Eclipse.

	h ' "				
	5 37 18.5	☉ R. Ascension			
	0 50 31.6	Apparent time			
	6	A	0.07384		
T	12 27 [illegible]	Co-t.	8.71470		
G	4° 11 13"	Tan.	8.86151	Co-s.	9.99[illegible]
	90	B	9.47656	C.	9.55401
F	1 15 23	Tan.	8.34112	Sec	10.00010
	95 26 36 = lon. N.	35 [illegible] 53		tan.	9.55297
Altitude Nonages.		70 57 46			

EXAMPLE II.

Required the altitudes and longitudes of the Nonagesimal at the times and places mentioned in the Example of Problem VII.?

Immersion.

	h ' "				
	12 20 50	☉ R. Ascension			
	16 57 29	Apparent time			
	6	A	0.12748		
T	16 18 [illegible]	Co-tan.	9.30053		
G	[illegible]° 18' 7"	Tan.	9.9[illegible]46	Co-s.	9.88939
	90	B	9.86761	C	10.09718
F	1[illegible] 57 48	Tan.	9.5[illegible]	Sec.	10.0[illegible]423
	119 15 55 = lon. N.	49 33 46		Tan.	9.93[illegible]71
Altitude Nonages.		81 17 32			

Emersion.

	h ' "				
	17 21 12.5	☉ R. Ascension			
	18 10 20	Apparent time			
	6	A	0.12748		
T	17 31 41.5	Co-tan	9.[illegible]822		
G	49° 50' 18"	Tan.	10.07[illegible]	Co-s.	9.[illegible]
	90	B	9.[illegible]761	C	10.[illegible]718
F	25 39 40	Tan.	9.[illegible]131	Sec.	10.[illegible]
	165 [illegible] 5[illegible] = lon. N.	37 17 39		Tan.	9.[illegible]
Altitude Nonages.		74 35 18			

In these calculations it is usual to take the sun's right ascension, and the apparent times, to tenths of a second, and to take proportional parts for the seconds and tenths in finding the logarithms. Thus in Example I. in finding the log. co. tang. of 9h. 43' 5".1; the nearest logarithms are 9.48849, 9.48804, corresponding to 9h. 43' 4", and 9h. 43' 12". These logarithms differ 45, the times 8", and the difference between 9h. 43' 4", and 9h. 43' 5".1, is 4".1. Hence 8" : 45 : : 4".1 : 23 the correction to be subtracted from the first log. 9.48849, (because it is decreasing) to obtain the sought log. co-tang. 9.48826.

* Thus if the time T is 5 hours, it must be called 5h. P. M. If T is 14 hours, it must be called 2h. A. M. In making use of a common table of logarithms, you must turn the time T into degrees, and [illegible] the log. co-tangent of its half.

† The arches F, G, are [illegible] when the time T is found in the column A. M. otherwise *obtuse*. This is easily [illegible] from the circumstance that a is the first letter of *acute* and A. M. Some writers have not taken notice of the cases of the values of F, G, within the polar circles.

‡ Strictly speaking, the quantity thus obtained is the distance between the north pole of the ecliptic and the zenith of the place, which, in all northern latitudes, and between the tropics, [illegible]
[illegible]

log. sine. The parallaxes may be calculated to the nearest second by proportional logarithms. When greater accuracy is required, common logarithms must be made use of.

To illustrate this rule, the following examples, corresponding to the times of the beginning and end of the total eclipse of the sun, of June 16, 1806, as observed at Salem, are given. The elements necessary for this purpose have already been calculated in Problems I. and IV. For greater accuracy the longitudes and latitudes of the moon are corrected for the errors — 58″.5 in longitude, and — 11″.4 in latitude, which were found by comparing several observations of the eclipse made at different places.

EXAMPLE I.

Given the altitude of the Nonagesimal 67° 58′ 50″, its longitude 63° 22′ 31″, the longitude of the moon 83° 49′ 3″.5 her latitude 24′ 27″.4 N. her horizontal parallax 60′ 24″.1, the latitude of the place of observation 42° 33′ 30″: required the parallaxes in longitude and latitude?

The correction in Table XXXVIII. corresponding to the latitude 42° 33′ 30″, and parallax 60′ 24″.1 is 5″.6, this and the sun's horizontal parallax 8″.8 subtracted from the ☽'s horizontal parallax 60′ 24″.1 leaves the *reduced* parallax 60′ 9″.7=3609″.7. The longitude of the Nonagesimal 63° 22′ 31″ subtracted from the moon's longitude 83° 49′ 3″, leaves the *moon's distance from the Nonagesimal*, 20° 26′ 32″ equal to the arch D, because less than 180°.

Calculation by common Logarithms.

Reduced par.	3609″ 7	Log.	3.55747
Alt. Nonag.	67 58 50	Sine	9.96710
☽'s true lat.	24 27.4	Sec.	10.00001
Constant log.			3 52458
D	20 26 32	Sine	9 54315
Appr. par.	1169″= 19 29	Log.	3.06773
D + Appr. par.	20 46 1	Sine	9 54970
Constant log.			3.52458
Cor. par.	=1187″=19 47	Log.	3.07428
D + cor. par.	20 46 19	Sine	9.54980
Constant log.			3 52458
Par. long. P 1186″.8=19′ 46.8		Log.	3.07438
☽'s true longitude	83 49 3.5		
☽'s app. long.	84 8 50.3		

Reduced par.	3609 7		Log.	3.55747
Alt. Nonag.	67 58 50		Co-si.	9.57394
☽'s app. lat.			Co-si.	10.00000
1 prt. p. 1353″.3	= +22′ 33″.3		Log.	3.13141
☽'s true latitude —	24 27.4			
☽'s approx. lat.	— 54.1		Sine	6.743
Reduced parallax			Log.	3 557
Alt. Nonag.			Sine	9.967
D + ½ P	20 36 25		Co-si.	9.971
2 part par.	— 1″ 7		Log.	0.238
Approx. lat.	— 1 54 1			
☽'s app. lat.	— 1 55 8	or	1′ 55″.8 N.	

EXAMPLE II.

Given the altitude of the Nonagesimal 70° 57′ 46″, its longitude 95° 26′ 36″, the longitude of the moon 85° 29′ 32″.6, her latitude 15′ 10″.4 N. her horizontal parallax 60′ 27″.0, the latitude of the place of observation 42° 33′ 30″. Required the parallaxes in longitude and latitude?

The correction in Table XXXVIII. corresponding to the latitude 42° 33′ 30″ and parallax 60′ 27″, is 5″.6, this and the sun's horizontal parallax 8″.8, subtracted from the moon's horizontal parallax 60′ 27″.0 leaves the *reduced* parallax 60′ 12″.6. The longitude of the Nonagesimal 95° 26′ 36″, subtracted from the moon's longitude increased by 360°, viz. 445° 29′ 33″, leaves the *moon's distance from the Nonagesimal* 350° 2′ 57″, the supplement of which to 360° is 9° 57′ 3″ equal the arch D.

By proportional logarithms.

Reduced par.	60′ 12″.6	P. L.	0.4756
Alt. Nonag.	70 57 46	Co-se.	10.0244
☽'s true lat.	15 10.4	Co-si.	10.0000
Constant log.			0.5000
D	9 57 3	Co-se.	10.7624
Approx. par.	9 50	P. L.	1.2624
D + appr. par.	10 6 53	Co.se.	10.7554
Constant log.			0.5000
Corrected par.	10 0	P. L.	1 2554
D + cor. par.	10 7 3	Co-se.	10.7553
Constant log.			0.5000
Par. long. P.	10 0.0	P. L.	1 2553
☽'s true long.	85 29 32.6		
☽'s app. long.	85 19 32.6		

Reduced par.	60′ 12.6		P. L.	0.4756
Alt. Nonag.	70 57 46		Sec.	10.4865
☽'s app. lat.			Sec.	10.0000
1 part par. lat.	+ 19 38 5		P. L.	0.9621
☽'s true lat.	— 15 10 4			
☽'s appr. lat.	+ 4 28 1		Co-se.	12.886
Reduced par.			P. L.	0.4756
Alt. Nonag.			Co-se.	10.0244
D + ½ P	10 2 3		Sec.	10.0067
2 part par. lat.	+ 4.4		P. L.	3.3927
Approx. lat.	+ 4 28.1			
Apparent lat.	+ 4 32 5	or	4′ 32″ 5 S.	

EXAMPLE III.

Required the parallaxes in longitude and latitude at the time of the occultation of Spica, Dec. 12, 1808, at the times and place mentioned in the Example of Problem VII.

Immersion.

Reduced par.	59' 50".9	P. L.	0.4782
Alt. Non.	81 17 32	Co-se.	10.0050
☽'s true lat.	1 55 11	Co-si.	9.9998
Constant			4830
D	50 52 1	Co-se.	10.1103
Appr. par.	45 55	P. L.	5933
D + appr. par.	51 37 56	Co-se.	10.1057
Constant			48.0
Corrected par.	46 25	P. L.	5887
D + corr. par.	51 38 26	Co-se.	10.1056
Constant			48.0
Par. long. P	+ 46 25	P. L.	5886
☽ true long.	200 7 55.3		
☽ app. long.	200 54 21.3		

....				0.4782
....			Sec.	0.8199
☽ app. lat.*		.	Sec.	10.0003
1 part par. lat.	+	9' 3".3	P. L.	1.2984
☽ true lat.	+	1 55 11.0		
☽ approx. lat.	+	2 4 14.3	Co-se.	11.4431
Reduced par.			P. L.	0.4782
Alt. Nonag.			Co-se.	10.0050
D + ½ P		51 15 13	Sec.	10.2045
2 part par. lat.	+	1 20.3	P. L.	2.1268
☽ approx. lat.	+	2 4 14.3		
☽ app. lat.	+	2 5 34.6 South.		
☽ par. lat.	+	10 23.6		

Emersion.

Reduced par.	59' 53".0	P. L.	0.4780
Alt. Non.	74 35 18	Co-sec.	10.0159
☽ true lat.	1 51 29.1	Co-sin.	9.9998
Constant			0.4937
D	35 22 38	Co-sec.	10.2374
Appr. par.	33 26	P. L.	7311
D + appr. par.	35 56 4	Co-sec.	10.2315
Constant			4937
Corrected par.	33 51	P. L.	7252
D + corr. par.	35 56 32	Co-sec.	10.2314
Constant			4937
Par. long. P.	+ 33 54	P. L.	7251
☽ true long.	200 51 36.1		
☽ app. long.	201 25 30.1		

....				0.4780
....			Sec.	10.5755
☽ app. lat.			Sec.	10.0003
1 part par. lat.	+	15' 54".2	P. L.	1.0538
☽ true lat.	+	1 51 29.1		
☽ approx. lat.	+	2 7 23.3	Co-sec.	11.4313
Reduced par.			P. L.	0.4780
Alt. Nonag.			Co-sec.	10.0159
D + ½ P		35 39 35	Sec.	10.0902
2 part par. lat.	+	1 44.2	P. L.	2.0154
☽ approx. lat.	+	2 7 23.3		
☽ appar. lat.	+	2 9 7.5 South		
☽ par. lat.	+	17 38.4		

Having thus explained the method of calculating the parallaxes of the moon, it now remains to give the rules for finding the longitude by eclipses and occultations. The main object in these calculations is to determine from the observed beginning or end of the eclipse or occultation, the precise time of the ecliptic conjunction of the sun, or star and moon free from the effects of parallax, counted on the meridian of the place of observation; since the difference of the times of conjunction, obtained in this manner at two places, will be their difference of longitude. If the lunar and solar tables were perfectly correct, the longitude might be determined by taking the difference between the time of conjunction, given in the Nautical Almanac, and that deduced from the observations of the eclipse or occultation; but it is much more accurate to compare the times deduced from observations actually made at the places for which the difference of longitude is sought. There are two different methods of finding the ecliptic conjunction, according as the latitude of the moon is supposed to be accurately known or not. If the latitude was given correctly by the lunar tables, or was accurately known by other observations, the ecliptic conjunction, and the longitude of the place might be determined by each of the phases of the eclipse or occultation, by the method given in Problems VIII. and IX. But the moon's latitude not being generally given to a sufficient degree of accuracy, it is usual to combine together the observations of the beginning and end of the eclipse or occultation, or the beginning and end of total darkness in a total eclipse, or the two internal contacts of an annular eclipse, to ascertain the error of the moon's latitude, by the method given in Problems VI. and VII. In making the calculations in these Problems, it will be necessary to know nearly the longitude of the place, in order to find the supposed time at Greenwich, so as to take out the elements from the Nautical Almanac: and if the longitude deduced from the observation should differ considerably, the operation must be repeated with the longitude obtained by this operation.

* The moon's true latitude 1° 55' 11" must first be used, its log. secant being 10.0002, which gives the 1st part par. 9' 3", which, added to the true latitude of the moon, gives the app. lat. nearly 2° 4' 14", the log. secant of which is 10.0003, as above. The calculation for the emersion is made in a similar manner.

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PROBLEM VI.

Given the latitude of the place, and the apparent times of the beginning and end of a solar eclipse, counted from noon to noon, according to the method of Astronomers, to find the longitude of the place of observation.

In the rule for solving this Problem, references will be made to fig. 12, Plate XII. in which DSE represents a small arch of the ecliptic; S, the place of the centre of the sun, supposed at rest; F, L, the apparent places of the centre of the moon at the beginning and end of the eclipse respectively; FD, SC, and AEL, are perpendicular to DE, FA parallel to DE, and SB perpendicular to FL. Then it is evident that FD, LE represent the apparent latitudes of the moon, which fall below DE if *south*, above if *north*; and SF, SL represent the sums of the corrected semi-diameters of the sun and moon, at the beginning and end of the eclipse respectively.

RULE.

To the apparent times of the beginning and end of the eclipse add the estimated longitude of the place in time if it is *west*, but subtract if *east*; the sum or difference will be the supposed time at Greenwich; corresponding to which, in the Nautical Almanac find, by Problem I. the moon's semi-diameter, horizontal parallax, longitude and latitude,* and the sun's semi-diameter, longitude and right ascension; also the moon's horary motion from the sun, by Problem II. Decrease the sun's semi-diameter $3\frac{1}{2}''$ for irradiation, and the remainder will be his *corrected* semi-diameter. Decrease the moon's semi-diameter $2''$ for inflexion, and to the remainder add the correction in Table XLIV,† the sum will be the moon's *corrected* semi-diameter. Find also, in the Nautical Almanac, the obliquity of the ecliptic.

With these elements and the apparent time at the place of observation, calculate the altitudes and longitudes of the Nonagesimal, by Problem IV; the parallaxes in longitude and latitude, and the moon's apparent longitudes and latitudes, by Problem V.

Take the difference between the *apparent* longitudes of the moon at the beginning and end of the eclipse, and subtract therefrom the difference of the sun's longitudes at the same times, the remainder will be the relative motion in longitude DE or FA. The relative motion in latitude AL, is found by taking the difference of the moon's *apparent* latitudes at the beginning and end of the eclipse, if they are both north, or both south, but their sum, if one be north, the other south. From the logarithm of FA, increasing the index by 10, subtract the logarithm of AL, the remainder will be the log-tangent of the *angle of inclination* DSB, this angle is to be taken *greater* than 90° when the moon's apparent latitude FD, at the beginning of the eclipse is *greater* than at the end EL, otherwise less.‡ Then to the log. co-secant of the angle of inclination, add the logarithm of the relative motion in longitude FA, the sum rejecting 10 in the index will be the logarithm of the apparent motion of the moon FL on her relative orbit. Then in the triangle SFL, the sides SF, SL, represent the sums of the *corrected* semi-diameters of the sun and moon at the beginning and end of the eclipse, and these with the relative motion FL, are given to find the angle FSB, (by Case VI. Obl. Trig.) Thus: to the log. ar. co. of FL, add the log. of the sum of SF and SL, and the log. of their difference, the sum rejecting 10 in the index will be the logarithm of the difference of the segments FB, BL; half of which, added to, and subtracted from half of FL, will give the two segments FB, BL, the greater segment being contiguous to the greater side, whether SF or SL. Then from the logarithm of the segment FB, increasing the index by 10, subtract the log. of SF, the remainder will be the log. sine of the angle FSB,‖ which is always less than 90°:

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* Corrected for the errors of the tables in longitude and latitude, when known.

† This correction must be found after the altitude and longitude of the Nonagesimal are calculated.

‡ This rule is equally true whether the latitude be of the same or different names. If the latitudes are equal and of the same name, the angle DSB will be 90°. If they are equal, but of different names, the angle DSB may be taken acute or obtuse, since in that case the angle FSB is 90°. Strictly speaking, when the points F, L, fall on different sides of the line DE, the angle DSB is *greater* or *less* than 90°: according as the expression $\frac{FD}{SF}$ is *greater* or *less* than $\frac{EL}{SL}$ but as the divisors SL and SF are nearly equal, they may be neglected, (as in the above rule) except in a case which very rarely occurs, namely, when the difference of SL, SF is greater than the difference of the two app. latitudes EL, FD, in which case the rule in this note must be made use of. Observing that the fractions $\frac{EL}{SL}$ $\frac{FD}{SF}$ represent the quotients of the moon's apparent latitudes divided by the sum of the semi-diameters of the sun and moon.

‖ When SF, SL are equal, or their difference is so small that it may be neglected, the log. sine of the angle FSB may be obtained much more expeditiously by subtracting the log. of the sum of SF and SL, from the log. of FL increasing the index by 10. This method may almost always be made use of without much error. It is the rule adopted by Doctor Mackay in his treatise on longitude.

the difference between this and the angle of inclination DSB, will be the *central angle* DSF.

To the log. co-sine of the *central* angle, add the log. of the sum of the corrected semi-diameters at the beginning of the eclipse SF, rejecting 10 in the index, the sum will be the logarithm of SD, the apparent difference of longitude of the sun and moon at that time. This is to be subtracted from the longitude of the sun at the beginning of the eclipse, if the central angle is less than 90°, but added if greater than 90°, the sum or difference will be the moon's apparent longitude: to this must be *added* the moon's parallax in longitude, when her distance from the Nonagesimal (found as in Problem V. by subtracting the longitude of the Nonagesimal from the moon's longitude, borrowing 360° when necessary,) is greater than 180°, otherwise the parallax must be *subtracted*; the sum or difference will be the moon's *true longitude* at the beginning of the eclipse.

Take the difference in seconds, between the sun's and moon's *true* longitudes at the beginning of the eclipse, to the logarithm of which, add the arith. comp. log. of the moon's horary motion from the sun* in seconds, and the constant logarithm 3.55630: the sum, rejecting 10 in the index, will be the logarithm of the time from the conjunction in seconds, which is to be added to the observed apparent time of the beginning of the eclipse, when the sun's longitude at that time is greater than the moon's *true* longitude, otherwise subtracted; the sum or difference will be the apparent time of the true ecliptic conjunction of the sun and moon at the place of observation. The difference between this and the time of conjunction at Greenwich, inferred from the Nautical Almanac by Problem III. will be the longitude of the place of observation. But if corresponding observations have been made at different places, it will be much more accurate to find the times of the conjunction at each place by the above rule, and the difference of those times will be the difference of meridians, if it does not differ much from the supposed difference of longitude. If there is considerable difference, the operation must be repeated, making use of the longitude found by this operation; and thus by successive operations, the true longitude may be obtained.

The long. of the place of observation being accurately known, the errors of the lunar tables in long. and latitude may be easily found. For the difference between the moon's *true* longitude deduced by the above method from the observations, and the longitude found from the Nautical Almanac will be the error of the tables in longitude. To find the error in latitude, add the log. sine of the central angle DSF to the log. of the sum of the corrected semi-diameters at the beginning of the eclipse SF, the sum rejecting 10 in the index will be the logarithm of the moon's apparent latitude FD at that time, which will be south, if the point F falls below D, otherwise north. Take the difference between this and the moon's apparent latitude found by Problem V. if they are both north, or both south; but their sum, if one be north and the other south, and the error of the tables in latitude will be obtained†.

REMARK.

The above rule will answer for deducing the longitude from the observed beginning and end of the internal contacts of a total or annular eclipse. The differences consist in reading the rule, beginning and end of the internal contacts, instead of beginning and end of the eclipse, and taking SF, SL equal to the differences of the corresponding semi-diameters instead of their sums.

EXAMPLE.

In Salem, in the latitude of 42° 33′ 30″ N. longitude by estimation 4h. 43′ 32″ W. from Greenwich, the beginning of the total eclipse of June, 1806, was observed at 15d. 22h. 6′ 18″.1, and the end at the 16d. 0h. 50′ 34″.6, apparent time, by astronomical computation. Required the longitude of the place of observation?

Most of the following elements are calculated in Problems I. II. IV. V.

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* When the horary motion varies, it must be taken to correspond to the middle time between the beginning of the eclipse, and the conjunction or new moon.

† When the eclipse or occultation is nearly central or (in other words) when FD, EL are very small in comparison of SF, the latitude thus found cannot be depended on, as a small error in the times of observation would produce a considerable error in the latitude. Indeed the case may occur when FD, EL are less than 30″, that it may be uncertain whether the points F, L, fall above or below the line DE, because the error of the lunar tables in latitude may sometimes be equal to 30″. In this case the correct latitude of the moon may be found (1) By observations made at another place where the eclipse or occultation was not so central. (2) By the number of digits eclipsed, if it was a solar eclipse. (3) By the difference of declinations of the moon and star observed before and after the immersion or emersion. (4) By the meridian altitude of the moon observed the same day, whence it may be found whether the moon was north or south of her place given by the tables.

ELEMENTS OF THE ECLIPSE.	BEGINNING.	END.
	d. h. ′ ″	d. h. ′ ″
Apparent times of observation	15 22 6 18.1	16 0 50 34.6
Estimated longitude W. from Greenwich	4 43 32	4 43 32
Supposed time at Greenwich	16 2 49 50.1	16 5 34 6 6
☉'s right ascension	5 36 50 0	5 37 18 5
Lat. of place 42° 33′ 30″—Reduc. Tab. XXXVIII. 11′ 26″	42 22 4	
Obliquity of the ecliptic	23 27 48	° ′ ″
☽'s long. by N. A—Err. Tab. 58″.5=True long. ☽ Prob. I.	83 49 3.5	85 29 32.6
Longitude of the Nonagesimal, by Prob. IV.	63 22 31	95 26 36
☽'s true long.—Long. Nonages=☽'s dist. from Nonages	20 26 32	350 2 57
This distance or supp. if greater than 180° is arch D.	D 20 26 32	D 9 7 3
Altitude of Nonagesimal Prob. IV.	67 58 50	70 57 46
☽'s horizontal parallax, by Prob. I.	60 24.1	60 27.0
—☉'s hor. par. 8″.8—Correction, Table XXXVIII. 5″.6	— 14 4	— 14.4
Reduced parallax	60 9 7	60 12.6
☽'s S. Diam. by N. A.—Inflexion 2″	16 25.7	16 26.4
Add correction Table XLIV.	15.2	16.4
☽'s corrected semi-diameter	16 40.9	16 42.8
☉'s semi-diameter by N. A. 15′ 46″.1—Irradiation 3″.5	15 42.6	15 42.6
Sum of the corrected semi-diameters	SF= 32 23.5	SL= 32 25.4
☽'s horary motion in longitude by Problem II. Ex. II.	36 39.2	36 42 8
☉'s horary motion	2 23.1	2 23 1
☽'s horary motion from the sun*	34 16 1	34 10 7
☽'s parallax in longitude P	19 46.8	10 0.0
☽'s apparent longitude—Error Tab. 58″.5, by Prob. 5.	84 8 50.3	85 19 32 6
☉'s longitude by Problem I.	84 41 3.4	84 47 35.5
DIFF. ☽'S APP. LONGITUDES=☽ app. mot.		1 10 42 3
DIFF. ☉'S LONGITUDES=☉ app. mot.		6 32.1
DIFFERENCE OF MOTIONS OF ☉ ☽		FA 64 10.2
☽'s true lat. by N. A. Prob. I.—Error Tab. 11″.4	— 24 27.4	— 15 10.4
☽'s app. lat. cor. for error Tab. 11″.4 by Prob. V.	FD=— 1 55.8	EL=+ 4 32.5
☽'S LAT. AT END—LAT. AT BEGINNING		AL=+ 6 28.3

As the apparent latitude at the beginning of the eclipse is north and at the end south, the point F corresponding to this example falls above DE, the point L below it. The rest of the calculation is as follows.

FA 64′ 10″.2=3850″.2 log. 13.58548			3.58548
AL 6 28.3 = 388.3 log. 2 58917			
Inclination 84° 14′ tan. 10.99631		Co-sec.	10.00220
Apparent motion FL	3869. 7	log.	3.58768
Its arith. comp.			6 41232
SF + SL = 64′ 48″.9	3888 9	log.	3.58988
Diff. SF, SL	1 9	log.	0 27875
Diff. segments	1 91	log.	0.28090
Its half	0 95		
Half of FL	1934 85		
Sum is great segment	1935 8		
Diff. is lesser seg. F B	1933 9	log.	13.28644
SF 32′ 23″ 5=	1943 5	log.	3 28858
Angle FSB	84° 19′	sine	9.99786
Inclination	84 14		
Diff. cent ang. DSF	0 5	co-sin.	10.00000
SF		log.	3.28858
SD=32′ 23″.5 =	1943 5	log.	3.28858

☉'s longitude	84° 41′ 3″.4	
SD	— 32 23 .5	
☽'s app. long.	84 8 39 .9	by obs.
☽'s par. long.	— 19 46 .8	
☽'s true long.	83 48 53 .1	
☉'s long.	84 41 3 .4	const. 3.55630
Diff. 3130″.3	= 52 10 3	log. 3.49553
☽ hor. mot. fr. ☉ 34′ 17″.1= 2057″.1	AC	6 68675
Time fr. conj. 1h. 31′18″.1=5478″.1	log.	3.73863
App. ti. obs.	15 22 6 18 1	
Ap. ti conj.	15 23 37 36.2	at Salem
Conjunct.	16 4 19	at Greenwich
Diff. Merid.	4 41 23.8	
....	sine	7.16270
....		3.28858
App. lat. FD=2″.8	log.	0.45128

In finding the time of conjunction or new moon, at Greenwich, 4h. 19′, in the Nautical Almanac, the longitude of the moon was supposed to be given correctly by the tables. If the calculation be made by Problem III. after allowing for the error—58″.5, the result will be 4h. 20′ 47″, whence the difference of Meridians=4h. 43′ 10″.8, which differs so little from the assumed longitude 4h. 43′ 32″, that it will not be necessary to repeat the operation. If the eclipse was observed at Greenwich, the time of conjunction ought to be determined thereby, in a similar manner to the above calculations; or by those of Problem VIII. if only one of the phases is observed: by this means the errors of the tables will be wholly avoided. If the eclipse was not

* This horary motion increases from 34′ 16″.1 to 34′ 19″.7 or 3″.6, during the eclipse 2h 44′ 16″.5, which is 1″.32 per hour. Now the ecliptic conjunction, or time of new moon at Greenwich by the N. A. was 4h 19′ or rather 4h. 20′ 47″, corresponding to 23h. 37′ 15″ at Salem, which is 1h. 30′ 57″ after the beginning of the eclipse: and the increase of the horary motion in half that time is 1″, which added to 34′ 16″.1, gives the horary motion 34′ 17″.1, corresponding to the middle time between the beginning of the eclipse and conjunction. This is used in calculating the correct time of conjunction.

observed at Greenwich, the observations at any other place whose longitude is known might be made use of, and thus the difference of meridians accurately obtained.

The moon's true longitude deduced from the above observation, is 83° 48′ 53″.1; by the N. A. it is 83° 50′ 2″.0, the difference — 68″.9 would be the error of the tables by this observation, if the assumed longitude 4h. 43′ 32″ and the solar tables were correct. By repeating the operation with the assumed longitude 4h. 43′ 10″.8 the error 68″.9 would be reduced to nearly the estimated value 59″.5.

The eclipse was so nearly central at Salem, that a variation of a minute in the moon's latitude, would hardly alter the times, or duration of the eclipse; so that the latitude could not be determined by the above observations to any considerable degree of accuracy. From this cause it happens that the app. latitude at the beginning of the eclipse is by the above calculation 2″.8 instead of 1′ 55″.8, as found by allowing the error 11″.4, deduced from other observations made where the eclipse was not so nearly central, and by the limits of the shadow of total darkness.

PROBLEM VII.

Given the latitude of the place and the apparent times of the beginning and end of an occultation of a fixed star by the moon, to find the longitude of the place of observation.

In the following rule reference will be made to fig. 13, Plate XII. in which DSE represents a parallel to the ecliptic passing through the place of the star S; SF, SL the corrected semi-diameters of the moon at the beginning and end of the occultation; DF, EL the differences between the apparent latitudes of the moon and the star, when of the same name, or their sums when of different names; either of these lines falling *below* DE if the moon's apparent latitude is more southerly than that of the star, otherwise above.

RULE.

To the apparent times of the beginning and end of the occultation add the estimated longitude of the place in time if it is *west*, but subtract if *east;* the sum or difference will be the supposed time at Greenwich; corresponding to which, in the Nautical Almanac, find by Problem I. the moon's semi-diameter, horizontal parallax, longitude and latitude,* and the sun's right ascension; also the moon's horary motion by Problem II. and the true longitude and latitude of the fixed star, by Table XXXVII. corrected for aberration and equation of equinoxes by Tables XL. XLI. Find also in the N. A. the obliquity of the ecliptic. To the moon's semi-diameter, add the correction in Table XLIV.† and from the sum subtract the inflection 2″, the remainder will be her *corrected* semi-diameter. With these elements and the apparent times at the place of observation, calculate the altitudes and longitudes of the Nonagesimal, by Problem IV. and the parallaxes in longitude and latitude, and the moon's apparent longitudes and latitudes by Problem V.

Take the difference between the *apparent* longitudes of the moon at the beginning and end of the occultation, which will be the moon's *apparent* motion in longitude, the logarithm of which, in seconds, being added to the log. co-sine of the *mean*‡ of the apparent latitudes of the moon at the beginning and end of the occultation, rejecting 10 in the index, will be the logarithm of the motion of the moon on the parallel FA. The relative motion in latitude AL, is found by taking the difference of the moon's *apparent* latitudes at the beginning and end of the eclipse if they are both north or both south; but their sum if one be north and the other south. From the logarithm of FA, increasing the index by 10, subtract the logarithm of AL, the remainder will be the log. tangent of the *angle of inclination* DSB, this angle is to be taken *greater* than 90° when the difference of the moon's and star's apparent latitudes at the beginning of the occultation FD is *greater* than at the end EL, otherwise less.§ Then to the log. co-secant of the angle of inclination, add the logarithm of the relative motion FA, the sum rejecting 10 in the index will be the logarithm of the apparent motion of the moon in her orbit FL.

Then in the triangle SFL, the sides SF, FL (representing the corrected semi-diameters of the moon at the immersion and emersion,) and the relative motion FL are given to find the angle FSB (by Case VI. Oblique Trig.) Thus: to the log. ar. co. of FL, add the log. of the sum of SF and SL, and the log. of their difference, the

* Corrected for the errors of the tables in longitude and latitude, when known.

† This correction must be found after the altitude and longitude of the nonagesimal are calculated.

‡ The mean latitude is half the sum of the two latitudes, if they are of the same name, but their half difference, if of different names. In solar eclipses, the correction for the mean latitude of the moon is neglected as too small to be taken notice of, the distance FA being taken equal to the difference of longitude DE (fig. 12, P. 12.)

§ This rule is equally true whether the points F, L fall on the same or on different sides of the line DE. If DF, EL are equal, and the points F, L fall on the same side of DE, the angle DSB will be 90°. If they are equal, and those points fall on different sides of the line DE, the angle DSB may be taken acute or obtuse. In strictness when the points F, L fall on different sides of DE, the angle DSB is greater or less than 90°, according as the quantity $\frac{FD}{SF}$ is greater or less than $\frac{EL}{SL}$.

EXAMPLE.

Suppose in a place in the latitude of 20° 0' N. longitude 1h .9m. 0s. east of Greenwich by estimation, the occultation of Spica by the Moon on Dec. 12, 1808, was observed the immersion at 16h. 57' 29" emersion at 18h. 10' 29", apparent time by astronomical computation. Required the longitude of the place of observation?

Most of the elements in the following Table are calculated by Problems I. II. and VI.

ELEMENTS OF THE OCCULTATION.	IMMERSION.		EMERSION.	
		d. h. ' "		d. h. ' "
Apparent times of observation		12 16 57 29		12 18 10 29
Estimated longitude E. from Greenwich		1 9 0		1 9 0
Supposed time at Greenwich		12 15 48 29		12 17 1 29
☉'s right ascension		17 20 59 0		17 21 12.5
Lat. of place 20° 0'—Reduc. Tab. XXXVIII. 7' 22"		19°52' 38"		
Obliquity of the ecliptic		23 27 39		° ' "
☽'s long. by N. A —Prob. I.		200 7 56.3		200 51 36.1
Longitude of the Nonagesimal, by Prob. IV. . . .		149 15 55		165 28 68
☽'s long —Long. Nonages= ☽'s dist. from Nonages .		50 52 1		35 22 38
This distance or its supp. to 360° is arch D.	D	50 52 1	D	35 22 38
Altitude of Nonagesimal Prob. IV.		81 17 32		74 35 18
☽'s horizontal parallax		59 52.3		59 54.4
—Reduction Table XXXVIII.		1.4		1.4
Reduced parallax		59 50.9		59 53.0
☽'s S. Diam. by N. A.—Inflexion 2"		16 16.9		16 17 5
Add correction Table XLIV.		10 4		13.3
☽'s corrected semi-diameter	SF	16 27.3	SL	16 30 8
☽'s horary motion in longitude in Problem II. Ex. 1*. .		35 51 7		35 54 2
☽'s parallax in longitude		48 25		33 54
☽'s apparent longitude		200 54 21.3		201 25 30.1
Difference of ☽'s app. longitudes				31 8.8
☽'s true lat. by N. A. Prob. I. . . . . . South		1 55 11.0		51 29 1
☽'s parallax in latitude		10 23.6		17 38 4
☽'s apparent latitude South		2 5 34.6		9 7.5
✱'s tr. lat = lat. T. XXXVII. 2° 2' 13".9. S.—T. XLI. 0".6		2 2 13.3		2 2 13.3
Difference ☽ ✱ app. lat	FD=	3 21.3	EL=	6 54 2
Difference of ☽'s app. latitudes			AL=	3 32 9
✱'s tr. long.=Long. Tab. XXXVII. 201° 10' 29".3+Tab. XL. 11".5—Tab. XLI. 10".1		201 10 30.7		

The difference of the apparent latitudes of the Moon and Star at the beginning of the occultation 3' 21".3 being less than at the end 6' 51" 2 the angle of inclination is less than 90°. In this example the moon's latitude is more southerly than the star's, hence the points F, L, fall below the line DE.

Diff. app. long. ☽	31' 8" 8=1868".8	log.	3·27 56		
☽'s mean app. lat.	2 7 21	cos.	9.99970		
Distance FA		log.	13.27126	. . . . . .	3.27126
☽'s diff. lat.	AL=3 32.9=212 .9	log.	2.32818		
Inclination	83° 30'	tan.	10.94308	co-secant	10 00280
Apparent motion FL	1879 .6	. . . .		. . . . . .	3 27406
Its arith. comp.			6.72594		
SF + SL =	32 58.1 = 1978 .1	log.	3 29625		
Diff. SF, SL	3 .5	log.	0 54407		
Diff. segments	3 .7	log.	0.56626		
Its half	1 .8				
Half FL	939 .8				
FR	938 .0	log.	2·97220		
SF	937 ·3	log.	2·99445		
FSR	71° 49'	sine	9 97775		
Inclination	83 30				
Diff. is cent. angle	11 41	co-sine	9 99091	. . sine	9 30643
SF		log.	2.99445	. . . . .	2 99445
Star's lat.	2° 2' 13"	sec.	10 00027		
				FD 199".9= 3' 19".9 lon.	2.30088
Diff. app. long. ☽ ✱	967".5 = 16 7.5	log.	2 98563		
✱ longitude	201 10 30 7			✱ lat.	2 2 13 .3
☽'s app. long.	200 54 23 2	by obs.		☽'s ap. lat.	2 5 33 .2 by obs.
☽'s par. long.	— 46 25			☽'s ap. lat.	2 5 34 .6 by N. A.
☽'s true long.	200 7 58.2	const.	3.55630	Error Tab.	— 1 ·4 in lat.
Diff. true long.	3752 5= 1 2 32.5	log.	3·57432	☽'s tr. lon.	200 7 58 .2 by obs.
☽'s hor. mot.	2153.5 35 53 5	log. co-ar	6.66686	☽'s tr. lon.	200 7 56 .3 by N. A.
Time	6273 1 44 33	log.	3 79748	Error Tab.	+ 1 .9 in long.
Immersion	16 57 29				
Conjunction	18 42 2	at place of observation			
Conjunction	17 33 0	at Greenwich.			
Diff. of meridians	1 9 2				

* The moon's horary motion varies from 35' 51".7 to 35' 54".2 during the occultation, hence at the middle time 17h. 49' 45" between the immer[illegible] ... 57' 29" and the conjunction 18h. 42' (deduced from the Nautical [illegible] horary mo[illegible] as is easily found by a calculation simi[illegible] lar to that in the [illegible]

The difference of meridians deduced from the observation 1h. 9′ 2″ differs but 2″ from the assumed quantity 1h. 9′ 0″. If the difference had been considerable, it would have been necessary to repeat the operation with the difference of meridians thus calculated, and so on till the assumed and calculated longitudes agree. The errors of the tables above found were deduced upon the supposition that the observations were actually made at the place mentioned in this example, and that the true longitude of the place of observation was 1h. 9′ 0″. For it must be observed, that the errors of the tables in longitude cannot be found by an observation of an eclipse or occultation without knowing by other observations the precise longitude of the place of observation. This is evident by observing, that by repeating the operation till the assumed and calculated longitude of the place of observation agree with each other, the long. of the moon deduced from the calculation will agree also with the longitude by the tables. The time of conjunction at Greenwich 17h. 33′ 0″ taken from the Nautical Almanac is liable to a small error from the incorrectness of the tables. To obviate this error it will be necessary to deduce (by the above method or by Problem IX. when only the beginning or end is observed) the time of conjunction from observations actually made at two places, the difference of these times will be the difference of meridians free from the errors of the tables.

PROBLEM VIII.

To find the longitude of a place by an eclipse of the sun when the beginning or end only is observed, the apparent time being estimated from noon to noon, according to the method of astronomers; the latitude of the place being also known.

RULE.

To the apparent time apply the estimated longitude of the place in time, by adding if *west*, subtracting if *east*, the sum or difference will be the supposed time at Greenwich. Corresponding to this time in the Nautical Almanac, find by Problem I. the moon's semi-diameter, horizontal parallax, longitude, and latitude;* and the sun's semi-diameter, longitude, and right ascension; also the moon's horary motion from the sun by Problem II. Decrease the sun's semi-diameter 3½″ for *irradiation*. Decrease the moon's semi-diameter 2″ for *inflexion*, and to the remainder add the correction in Table XLIV.† the sum will be the moon's *corrected* semi-diameter. Find also, in the Nautical Almanac, the obliquity of the ecliptic.

With these elements and the apparent time at the place of observation calculate the altitude and longitude of the nonagesimal by Problem IV. and the parallaxes in longitude and latitude and the moon's apparent latitude by Problem V.

To the sum of the corrected semi-diameters of the sun and moon *add* and *subtract* the moon's apparent latitude, and find the logarithms of the *sum* and *difference* in seconds. Half the sum of these two logarithms will be the logarithm‡ of an arch in seconds, to be added to the sun's longitude if the phase is after the apparent conjunction, but subtracted if before;§ the sum or difference will be the *apparent* longitude of the moon. To this add the moon's parallax in longitude when the moon's distance from the nonagesimal (found as in Problem VI. by subtracting the longitude of the nonagesimal from the moon's longitude, borrowing 360° when necessary) is greater than 180°, otherwise subtracted, the sum or difference will be the *true* longitude of the moon.

Take the difference in seconds between the true longitudes of the sun and moon, and to its logarithm add the arithmetical complement log. of the moon's horary motion from the sun in seconds and the constant logarithm 3.55630, the sum, rejecting 10 in the index, will be the logarithm‡ of the correction of the given time expressed in seconds. This is to be added to the apparent time of observation when the moon's true longitude is less than the sun's, otherwise subtracted; the sum or difference will be the time of the true conjunction at the place of observation. The difference between this and the time of conjunction inferred from the Nautical Almanac for the meridian of Greenwich by Problem III. will be the longitude of the place of observation in time, supposing the lunar and solar tables to be correct; but it is much more accurate to compare actual observations made at different places, by deducing the times of the ecliptic conjunction from each observation, the difference of these times will be the difference of longitude.

EXAMPLE.

In Salem in the latitude of 42° 33′ 30″ N. longitude by estimation 4h. 43′ 32″ W. from Greenwich, the beginning of the total eclipse of June, 1806, was observed at 15d. 22h. 6′ 18″.1 apparent time by astronomical computation. Required the longitude of the place from this observation?

The elements must be calculated as in the example of Problem VI. for the beginning of the eclipse, except those marked in italics. The rest of the calculation may be made by proportional logarithms as follows:

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* The longitude and latitude must be corrected for the errors of the tables, when known by a previous operation, or by other observations.

† This correction must be found after the altitude and longitude of the nonagesimal are calculated.

‡ These calculations may be made in the same manner by using proportional logarithms, the only difference consists in using the constant logarithm 0.4771 instead of 3.55630 in finding the time of conjunction.

§ In general, the beginning of an eclipse or occultation precedes the apparent conjunction, and the end is after the apparent conjuction, but there is a case (which very rarely occurs) where the contrary may take place: namely, where the point F or L, (P. XII. fig. 12, 13,) falls between C and B, which can happen only when the lines FD, EL are nearly equal to SF or SL. In this case it may be ascertained whether the phase precedes or follows the conjunction by making the calculation as in Prob. VI. or VII. with the times of beginning and end, calculated by Problem XIII. and as the central angle is greater or less than 90°, the phase will follow or precede the apparent conjunction. The latitudes given by the tables being supposed correct.

Sum semi-diam. ☉ ☽	35′ 21″.5		
☽ App. lat.	1 55 .8		
Sum	34 19 .3	P. L.	0.7197
Diff.	30 27 .7	P. L.	0.7715
		Sum	1.4912
Half sum	Arch 32 20	P. L.	7456
☉ Longitude	84 41 3 .4		
☽ App. long.	84 8 43 .4		
☽ Par. long.	— 19 46 .8		
☽ True long.	83 48 56 .6		
☉ True long.	84 41 3 .4	Cons. log.	0.4771
Difference	52 6 .8	P. L.	0.5383
☽ Hor. mot. fr. ☉	34 17 .1	A. Co. P. L.	9.2799
Time from conj.	1h. 31′ 13″	P. L.	0.2953
App. time obs.	15 22 6 18		
App. conj. Salem	15 23 37 31		
App. conj. Green.	16 4 19 by N. A.		
Diff. Merid.	4 41 29		

If we suppose the time of conjunction at Greenwich to be 4h. 20′ 47″, as calculated in the Problem VI. the difference of meridians would be 4h. 43′ 16″, agreeing nearly with the assu gitude, so that it will not be necessary to repeat the operation. The remarks at the end of ample, respecting the errors of the lunar tables, and the comparing of actual observations at places, are equally applicable to the present Problem.

PROBLEM IX.

To find the longitude of a place by an occultation of a fixed star by the moo the immersion or emersion only is observed, the apparent time being estimat noon to noon, according to the method of astronomers, and the latitude of th being known.

RULE.

To the apparent time apply the estimated longitude of the place turned in by adding if *west*, subtracting if *east*, the sum or difference will be the suppo at Greenwich. At this time find in the Nautical Almanac the sun's right as the moon's semi-diameter, horizontal parallax, longitude and latitude* by I. and the moon's horary motion by Problem II. also the latitude and long the fixed star by Table XXXVII. and correct it for aberration and equation noxes by Tables XL. XLI. Decrease the moon's semi-diameter 2″ for inflexi to the remainder add the augmentation from Table XLIV.† the sum will be *rected* semi-diameter. Find also, in the Nautical Almanac, the obliquity ecliptic. With these elements and the apparent time of observation calcu altitude and longitude of the Nonagesimal by Problem IV. also the parall longitude and latitude and the moon's apparent latitude by Problem V.

Take the difference between the latitude of the star and the app. lat. of th which add to, and subtract from the moon's corrected semi-diameter (these ties being expressed in seconds) half the sum of the logarithms of these quant creased by the log. secant of the star's latitude, rejecting 10 in the index, wil logarithm‡ of an arch in seconds to be added to the star's longitude if the m passed the apparent conjunction, but subtracted if *before*; the sum or differe be the *apparent* longitude of the moon. To this add the moon's parallax in lo when the moon's distance from the nonagesimal (found as in Problem VII. tracting the longitude of the nonagesimal from the moon's longitude, borrowi when necessary) is greater than 180°, otherwise subtract it, the sum or dif will be the *true* longitude of the moon. Take the difference in seconds betw moon and star's true longitudes, and to its logarithm add the arithmetical co of the moon's horary motion and the constant logarithm 3.55630, the sum re 10 in the index, will be the logarithm‡ of a correction in seconds to be applie given time of observation by *adding* when the moon's true longitude is less t star's otherwise *subtracting*, the sum or difference will be the time of the tr junction at the place of observation. The difference between this and the conjunction inferred from the Nautical Almanac by Problem III. for the m of Greenwich will be the longitude of the place of observation, if the tables a rect; but it is much more accurate to compare the times of conjunction d

* Corrected for the errors of the tables in longitude or latitude when known.

† This correction must be found after the altitude and longitude of the nonagesimal are [illegible]

‡ Proportional logarithms may be used instead of common logarithms, the constant logarit[illegible]

[illegible]

from actual observations at the different places in the manner mentioned at the end of the rule given in Problem VII.

EXAMPLE.

Suppose in a place in the latitude of 20° 0′ N. longitude by estimation 1h. 9′ 0″ east from Greenwich, the emersion of the star Spica was observed on December 12, 1808, at 18h. 10′ 29″, apparent time by astronomical computation. Required the longitude of the place of observation?

The elements must be calculated as in the example of Problem VII. for the emersion of Spica. The rest of the calculation, made by common logarithms is as follows.

☽ Semi-diameter	16′ 30″.8 = 990″.8				
Diff. app. lat. ☽ ✱	6 54 .2 414 .2				
Sum	1405 .0	log. 3.14768			
Difference	576 .6	log. 2.76087			
	Sum	5.90855	Its half		2.95427
			✱ lat. 2° 2′ 13″. Sec.		10.00027
Arch	15′ 0″.6	=	900″.6	log.	2.95454
✱ longitude	201 10 30 .7				
☽ app. long.	201 25 31 .3				
☽ par. long.	— 33 54				
☽ true long.	200 51 37 .3		Constant	3.55630	
Diff. true long. ☽ ✱	18 53 .4	= 1133.4	log.	3.05438	
☽ horary motion	35 54 .7	= 2154.7	co. log.	6.66661	
Time	31 34	= 1894	log.	3.27729	
Time of obs.	18 10 29				
Conj. at place obs.	18 42 3	by obs.			
Conj. at Greenwich	17 33 0	by N. A.			
Difference merid.	1 9 3				

The difference of meridians by calculation 1h. 9′ 3″ differs but 3″ from the assumed longitude, so that it will not be necessary to repeat the operation. All the remarks made at the end of the example in Problem VII. are applicable to this problem. It may also be further observed, that the emersion or immersion which happens on the dark limb of the moon can be observed with much more accuracy than on the enlightened limb; because the light from this limb prevents the observer from perceiving the star's immersion or emersion so instantaneously as on the dark side of the moon.

PROBLEM X.

To calculate an eclipse of the moon.

The time of beginning or end of a lunar eclipse at any place may be found by subtracting or adding the longitude to the times given in the Nautical Almanac for the meridian of Greenwich, according as the longitude is west or east. But as some readers may wish to know the method of deducing these times from the longitudes, latitudes, &c. of the moon and sun, given by the Nautical Almanac or by other tables, it was thought proper to insert the rule for these calculations.

An eclipse of the moon can only happen at the time of the full moon. If her longitude at that time is not distant from either node* of the moon's orbit more than about 12°, there may be an eclipse. To find whether there will be one, and to calculate the times and phases proceed as follows.

RULE.

Find the time of full moon at Greenwich by the Nautical Almanac or Problem III. to which *add* the longitude of the place turned into time if *east*, but *subtract* if *west*, the sum or difference will be the time of the ecliptic opposition at the proposed place.

For the time at Greenwich find by Problem I. the moon's latitude, horizontal parallax and semi-diameter, (which requires no augmentation) also the sun's semi-diameter. Then by Problem II. the horary motion of the moon from the sun in longitude, and the moon's horary motion in latitude.

Draw the line ACB (Plate XII. fig. 6) and perpendicularly thereto the line PCR. Select a scale of equal parts to measure the lines of projection, and from it take CG equal to the moon's latitude, and set it on CR from C to G, *above* the line AB if the latitude of the moon is *north*, below if south.† Take CO equal to the horary motion of the moon from the sun in longitude and set it on the line CB to the right of

* The longitude of the moon's ascending node is given in the third page of the Nautical Almanac. The longitude of the other node is found by adding or subtracting 6 signs.

† The northern latitudes found by Prob. I. have the sign —, the southern +. In the figure the latitude is south. If it had been north the point G must have been placed on the continuation of RC above C.

C, from C to O. Take CP equal to the moon's horary motion in latitude, as found with its sign by Problem II. and set it on the line CB from C to P, *above* the line AB if its sign is —, *below** if +. Join OP which is equal to the horary motion of the moon from the sun, and parallel thereto through G draw the relative orbit of the moon from the sun NGL, on which are to be marked the places of the moon before and after the full, by means of the horary motion OP, so that the moment of full moon, or ecliptic opposition at the proposed place may fall exactly on the point G. This may be done by making the extent OP equal to the transverse distance of 60.60, on the line of lines of the sector, then measuring from the same lines the transverse distance corresponding to the minutes and parts of a minute in the time of full moon at the place of observation, and setting it on the line GN from G towards the right to the point *x*, where the whole hour preceding the full moon is to be marked.† Then the distance OP set from *x* to the right hand on the line LGN reaches to the hours preceding the full moon, and set to the left hand reaches successively to the following hours. These intervals are to be divided into sixty equal parts representing minutes, if the size of the scale will admit of it.

Add 50″ to the moon's horizontal parallax‡ and from the sum subtract the sun's semi-diameter, the remainder will be the semi-diameter of the shadow CB, with which describe the circle ASB about the centre C. Add the moon's semi-diameter to the radius CB, and with that radius describe, about the centre C, the circle DRM, which if there be an eclipse will cut NL in the points E, H, representing respectively the places of the moon at the beginning and end of it. If there is no intersection there will be no eclipse. Draw the line CKST perpendicular to LN, cutting it in K and meeting the circles ASB, DRH in S, and T. With a radius equal to the moon's semi-diameter describe about the centres E, H, K, the small circles represented in the figure; of which that drawn round K cuts the line CKS in the points I, F, and if the eclipse is total the whole of this circle will fall within ASB, as in fig. 6, but if part of the circle falls without ASB as in fig. 7, P. XII. the eclipse will be partial. In either case the number of digits eclipsed may be obtained by saying as the diameter of the moon FI is to the obscured part FS so are 12 digits to the number of digits eclipsed. When the eclipse is total, the beginning and end of total darkness may be found by taking a radius equal to CB decreased by the moon's semi-diameter, and sweeping with it round the centre C, a circle *d e h m*, cutting LN in the points *e*, *h*, representing respectively the points of beginning and end of total darkness. Then the hours and minutes marked in the line NL, at the points E, *e*, K, *h*, H, will represent respectively the times of the beginning of the eclipse, beginning of total darkness, middle of the eclipse, end of total darkness, and end of the eclipse. In this rule no allowance is made for the oblate figure of the earth, the correction from this source being much less than the errors of observation.

EXAMPLE.

Required the times of beginning, end, &c. of the eclipse of the moon of May 9th, 1800, at a place in the longitude of 30° W. from Greenwich.

By the Nautical Almanac the time of full moon at Greenwich was May 9th, at 19h. 39′. From this subtracting the longitude of the place of observation 30° W. or 2h. the remainder 17h. 39′ was the time of full moon at the place of observation. Corresponding to the time at Greenwich, 19h. 39′, the elements in the adjoined table were calculated by Prob. I. and II. and the values CB, CD, Cd, found by the above rule. Upon the centre C with the radii CB, CD, Cd, taken from a scale of equal parts, describe the circles ASB, MRD, *med*. Draw the line ACB representing the ecliptic, and

Elements of the Eclipse May 9, 19h. 39′				
App. time conj. Greenwich, May 9		19h.	39′	
Long. place 30° W		2	0	
time conj. at place obs.		17	39	
☾'s Lat. by Prob. I. S. decreasing	CG +	0	44″	.8
☾'s Hor. Paral.		61	13	.5
☾'s semi-diameter	RD	16	40	.7
☉'s semi-diameter		15	51	.3
☾'s Hor. Mot. in long. Prob. II.		37	37	.3
☉'s Hor. Mot. in long.		2	24	.6
☾'s Hor. Mot. from ☉ in long.	CO	35	13	.0
☾'s Hor. Mot. in lat. Prob. II.	CP —	3	38	.3
☾'s Hor. Par. +50″ — ☉'s S. D.	= CB	46	12	.2
CB + ☾'s S. D.	= CD	62	52	.9
CB — ☾'s S. D.	= Cd	29	31	.5

* In other words the point P will fall above C if the moon is approaching to the north pole of the ecliptic, otherwise below. That is, the point P must fall above C if the moon's latitude is south decreasing or north increasing, otherwise below. When no great accuracy is required the horary motion in latitude need not be found by Prob. II. instead of which the angle COP may be taken equal to 5° 40′, in eclipses of the moon or sun, and the line OP equal to CO increased by 9″ or 10″; but this method will not answer in occultations, in which the angle COP varies above 5 degrees.

† The distance Gx may also be found by common arithmetic by saying as 60 minutes are to the minutes and seconds in the time of full moon (which in the present example is 39′) so is OP to Gx. After marking the hours on the line LGN it is usual to divide them successively into halves and quarters of an hour, then into five minutes and one minute.

‡ The semi-diameter of the shadow is increased by the earth's atmosphere from 20″ to 60″, according to the estimates of different astronomers. Mayer supposes this correction to be one 60th part of the shadow, varying from 37″ to 46″. The mean of Mayer's correction added to the sun's parallax is nearly equal to 50″ assumed as above.

make CG perpendicular thereto equal to the moon's latitude 10′ 44″.8 S. the point G being taken below C because that latitude is south. Make CO equal to the horary motion of the moon from the sun in longitude 35′ 13″.0, and CP perpendicular thereto equal to the horary motion in latitude—3′ 28″.2, the point P being placed above C, because the moon's horary motion in latitude has the sign — prefixed, or in other words, the latitude was south decreasing. Join OP, and parallel thereto draw through G the line NGL, and on it let fall the perpendicular CK. Make the distance OP a transverse distance of 60,60 on the line of lines of the sector, and measure from the same lines the transverse distance 39,39 (corresponding to the minutes in the time of full moon at the place of observation) this distance, set on the line GN, to the right of G, reaches to the point x, where the hour 17h preceding the full moon is to be marked. Take the extent OP and lay it from 17h. to the right hand to 16h. and successively to the left to 18h. 19h. &c. Subdivide these lines into 60 equal parts, representing minutes, if the scale will permit, and the times corresponding to the points E, e, K, h, H, will represent respectively the beginning of the eclipse 15h. 56m. the beginning of total darkness 16h. 54m. the middle of the eclipse 17h. 41m. the end of total darkness 18h. 28m. and the end of the eclipse 19h. 26m. which times agree nearly with those in the Nautical Almanac, allowing for the difference of meridians 2 hours.

Calculation by Logarithms.

The phases of the eclipse may also be calculated by logarithms in a very simple manner. Thus suppose it was required to find the time of the beginning of the eclipse in the above example. In this case in the right-angled triangle OCP, there would be given CO=2113″.0 and CP=208″.2, to find OP=2123″.2 and the angle OPC=84° 22′. This angle is equal to RGE, because GE, OP are parallel, and its supplement gives the angle CGE=95° 38′. Then in the triangle CGE there are given the angle CGE=95° 38′ the moon's latitude CG=644″.8, and the line CE (=CD) =3772″.9 to find CEG=9° 48′, GCE=74° 34′ and GE=3654″.5. Then say as OP (2123″.2) is to 1 hour (3600″.) so is GE (3654″.5) to the time (6196″=)1h. 43′ 16″ between the begining of the eclipse and the full moon at the place of observation 17h. 39′, and as the point E falls to the right hand of G, that time must be subtracted from 17h. 39′, to obtain the time of the beginning of the eclipse 15h. 55′ 44″, which agrees nearly with the projection. As these calculations are very simple it will be unnecessary to take notice of the different cases, or to give the calculations at full length, the whole being sufficiently evident from the figure. The middle of the eclipse is found by means of the triangle GKC similar to OCP, in which the angles and hypotenuse CG are given to find CK, KG. The time of describing KG being added to, or subtracted from the time of full moon at the place of observation, according as the point K falls to the left or right of G, will give the time of the middle of the eclipse. The distance CK 10′ 41″.7 subtracted from the radius CD or CT=62′ 52″.9 will leave a remainder equal to the eclipsed part FS (=KT) 52′ 11″.2. And the moon's diameter 33′ 21″.4 is to FS 52′ 11″.2 as 12 digits to the digits eclipsed 18¾. In making these calculations common or proportional logarithms may be made use of.

PROBLEM XI.

To project an eclipse of the sun for any given place.

An eclipse of the sun can happen only at the time of new moon. If the moon's longitude at that time is not distant from either node of the moon's* orbit more than 17¼° there may be an eclipse. To find whether there will be one, and to calculate the times and phases proceed by the following

RULE.

To the time of the new moon given in the Nautical Almanac (or calculated by Problem III.) add the longitude of the proposed place, turned into time, if east, but subtract if west, the sum or difference will be the time of conjunction at the proposed place. Corresponding to the time of new moon at Greenwich, find by Problem I. the moon's latitude, horizontal parallax, and semi-diameter, also the sun's longitude, semi-diameter and declination. Then by Problem II. find the horary motion of the moon in latitude and the horary motion of the moon from the sun in longitude.

Draw the line ACB (Plate XII. fig. 10.) representing the ecliptic and perpendicularly thereto, the line PCR. Take a scale of equal parts to measure the lines of the projection; measure from it an interval equal to the moon's latitude and apply it on CR from C to G, *above* the line ACB if the moon's latitude is *north*, *below*, *if south*.† Take CO equal to the horary motion of the moon from the sun in longitude and set it on the line CB to the right hand of C to O; take CP equal to the moon's horary

* See note with this mark in page 575. All the eclipses that can happen in any part of the earth are indicated in the Nautical Almanac.

† In the figure the latitude is supposed north. If it had been as much south the point G would have been as much below C as it is now above it.

—Draw the line CZ′ meeting the sun's disc in the points *a*, *c*, the point *c* being the most distant from the centre C. Then the circle *g a c* being held between the eye of the observer and the sun, the engraved or marked side of the figure towards the eye, and the line *c a* in a vertical direction with the point *c* uppermost, will represent the appearance of the sun as viewed by the naked eye at that time, *c* will represent the upper part of the sun, *a* the lowest, and *g* the point of contact. If the eclipse be observed with an inverting telescope, the contrary will be observed; that is, the part *a* must be uppermost, *c* the lowest, and *g* the point of contact will appear to the left hand of *ca*. In a similar manner the appearance of the objects may be obtained at any other part of the eclipse, but it is not necessary except at the beginning of it; where there is nothing to direct the eye of the observer.

EXAMPLE.

Required the times and phases of the total eclipse of the sun of June 16, 1806, at Salem in the latitude of 42° 33′ 30″ N. and the longitude of 4h. 43m. 32s. west from Greenwich.

By the Nautical Almanac the time of New Moon at Greenwich was June 16d. 4h. 19′, corresponding to June 15, 23h. 35′ 28″, at Salem. At the time at Greenwich, 4h. 19′ the elements of the eclipse were as in the adjoined table calculated by the above rule.

ELEMENTS.

		h.	m.	
Conjunction at Greenwich, June 16,		4	19	
Salem W. from Greenwich		4	43	32
Ecliptic conjunc. at Salem, June 15,		23	35	28
Latitude of Salem		42	33	30
☽'s Horizontal Parallax			60	25 7
☉'s Horizontal Parallax				8.8
☽'s Reduced Horizontal Parallax			60	16.9
☽'s Semi-diameter			16	28.1
☉'s Semi-diameter			15	46.1
Sum of Semi-diameters			32	14.2
Difference of Semi-diameters				42.0
☽'s Horary motion in Long. Prob. II.			36	41.2
☉'s Horary motion N. A.			2	23.1
☽'s Horary motion from ☉	CO		34	18.1
☽'s Horary motion in latitude	CP	+	3	22 5
☽'s Latitude by Prob. I.	CG	—	19	37
☉'s Longitude	TV	84	44	36
☉'s Declination	DF	23	22	N.

Draw ACB (Plate XII. fig. 10,) and perpendicular thereto the line CGR. Make CG equal to the moon's latitude 19′ 37″ N. taken from a scale of equal parts, the point G being above C because the latitude is north. Make CO equal to the moon's horary motion from the sun 34′ 18″.1, to the right hand of the point C; and CP equal to the moon's horary motion in latitude + 3′ 22″.5, the point P being below C because this horary motion has the sign + prefixed. Draw NGL parallel to OP. Make OP a transverse distance of 60, 60; on the line of lines of the sector and measure from the same lines the transverse distance 35½, 35½ (corresponding nearly to the minutes in the time of new moon) this distance set on the line GN to the right of G reaches to the point *x* where the hour preceding the new moon is to be marked, viz. 23h. Take OP in the compasses and mark it successively on the line NL from *x* or 23h. to the right to 22h. and to the left to 24h. or 0h. 1h. &c. These are subdivided into five minutes, the scale not admitting smaller divisions. Take the moon's reduced horizontal parallax 60′ 16″.9 from the scale of equal parts, and with that radius describe about the centre C the circle ARB. Set off (by means of the sector) the arches RT, RU, each equal to 23° 28′. Join TQU and about that diameter describe the circle TYU. Make the arch TV equal to the sun's longitude 84° 44′ 36″, which is done by setting the radius QT as a chord from T to ♊, and then the arch ♊V=24° 44′ 36″ by means of the sector. Draw P′V parallel to CR to meet TU in the point P′. Join CP′ and continue it to meet the circle ARB in W. Make (by the sector) the arches WD, W*d*, equal the complement of the latitude of the place 47° 26′½ nearly, the radius being CB. In a similar manner make the arches DF, DE, *df*, *de*, &c. each equal to the sun's declination 23° 22′. Draw the lines F*lf*, D*qd*, E*ne*, cutting CW in *l*, *q*, *n*. Bisect *ln* in *r*. Draw the line VI, *r*, XVIII parallel to D*qd* and make *r*, VI, *r*, XVIII, each equal to *q*D. Through the points *l*, VI, *n*, XVIII, *l*, draw the path of the spectator as taught in the above rule, and mark the hour of noon 0h. at the point *n* because the sun's declination is north. Mark the following hours in succession to the left I, II, III, &c. as in the figure. Take an extent in the compasses equal to the sum of the semi-diameters of the sun and moon 32′ 14″.2 and beginning towards N, find, as above directed the points *p*′ Z′, at that distance apart and marked with the same time 22h. 7′ nearly, which is the time of the beginning of the eclipse. Proceed in the same way for the end of the eclipse corresponding to the points *p*″, Z″, and to the time 0h. 53′ which is the time of the end of the eclipse. Take the difference of the semi-diameters of the sun and moon 42″ in the compasses, and proceed in the same way to find the beginning and end of total darkness 23h. 27m. and 23h. 31m. The points corresponding could not be drawn in the figure as they are so near to *p* and Z, and the scale small. Find by trials the points *p* Z marked with the same time and at the least distance apart, this will be the time of the middle of the eclipse 23h. 29′. With an extent equal to the moon's semi-diameter 16′ 28″.1 as a radius, describe about *p* the circle whose diameter is M*m* representing the moon's disc, and with the sun's

before. Whence the times of beginning and end of the eclipse may be found as in the above rule. An example of this method is not given as it would render the scheme too confused.

PROBLEM XII.

To project an occultation of a fixed star by the moon at any given place.

The method of projecting an occultation is nearly the same as that of an eclipse of the sun, but to save the trouble of reference it was thought expedient to give the rule without abridgment.

RULE.

To the time of the ecliptic conjunction of the moon and star, given in the first page of the Nautical Almanac (or calculated by Prob. III.) add the longitude of the proposed place turned into time, if east, but subtract if west, the sum or difference will be the time of conjunction at the proposed place. Corresponding to the time of conjunction at Greenwich, find by Problem I. the moon's latitude, horizontal parallax and semi-diameter, also the sun's right ascension. Then by Problem II. find the horary motion of the moon in longitude and latitude, and by Tables VIII. and XXXVII. the star's Right Ascension, Declination, Longitude and Latitude¶.

Draw the line ACB (Plate XII. fig. 8.) representing a parallel of the ecliptic passing through the star, and perpendicular thereto the line CPR. Take a scale of equal parts to measure the lines of the projection, and from it take an interval equal to the difference of the latitudes of the moon and star, and apply it to the line CR from C to G *above* the line ACB if the moon's latitude is north of the star's, otherwise *below*‡*. Take CO equal to the horary motion of the moon in longitude, and set it on the line CB to the right hand of C to O; take CP equal to the moon's horary motion in latitude found with its sign by Problem II. and set it on the line CR from C to P, *above** the line ACB, if its sign is —, below if +. Join OP which represents the horary motion of the moon on her orbit, and parallel to that line draw the orbit of the moon NGL; on which are to be marked the places of the moon before and after the conjunction by means of the horary motion OP, so that the moment of the ecliptic conjunction at the proposed place may fall exactly at the point G, as in the figure where the conjunction is at 18h. 42′. This may be done by making OP equal to the transverse distance 60, 60 on the line of lines of the sector, then measuring from the same lines the transverse distance corresponding to the minutes and parts of a minute in the time of the ecliptic conjunction at the place of observation, and setting it on the line GN from G towards the right to the point x, the place of the moon at the first whole hour† preceding the conjunction (which in the present figure is 18h.) Then the distance OP being taken in the compasses and set from x to the right hand gives successively the preceding hours, and the same distance set to the left gives the following hours, as in the figure, where they are marked 17h. 18h. 19h. 20h. These hours are to be divided into 60 equal parts representing minutes, the scale being taken sufficiently large for that purpose‡. In the present figure the subdivisions are carried only to five minutes. Take the moon's horizontal parallax from the scale of equal parts for the radius CB; with which on the centre C, describe the circle BRA cutting CR in R. Open the sector till the transverse distance 60°, 60° on the line of chords is equal to the radius CB, and measure from that line the transverse distance 23° 28′ (equal to the obliquity of the ecliptic) which set on the circle ARB on each side of R to T and U. Join TU cutting CR in Q. On Q as a centre with the radius QT describe a circle TYUV, on which set off the arch TYV, equal to the star's longitude. Through V draw the line VP′ parallel to CR. Open the sector till the transverse distance 90° 90° on the sines is equal to the radius CB, then take in the compasses from the same lines an extent equal to the transverse distance corresponding to the complement of the declination of the star, and with one foot in C sweep a small arch to cut the line VP′ in P′ the place of the pole of the earth.*† Draw CP′, and continue it on either side so as to cut the circle ARB in the point W situated *above* AB, if the latitude of the proposed place is *north*, but below if south. In the proposed figure the latitude is north. (If it had been south the lower part of the circle ARB ought to have been made use of.) Open the sector

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¶ In strictness these quantities ought to be corrected for Aberration and Nutation by Tables XXXIX.—XLIII. but the correction is so small that it may always be neglected. If the Right Ascension and Declination only are given the latitude and longitude may be found by Problem XIX: and if the latter are given, the former may be calculated by Problem XX.

‡* In the figure the point G is placed above ACB, because the moon is in a less southern latitude than the star. This part of the rule may also be thus expressed. Find the moon's latitude with its sign as in Problem II. Prefix the sign + to the star's latitude if north, the sign — if south. Add the latitudes noticing the signs as in algebra, and the distance CG will be obtained. If its sign is — the point G is to be placed above C, but below C if the sign is +.

* See note with this mark in page 576.

† See note with this mark in page 576.

‡ See note with this mark in page 578.

*† The distance of the line WV from the line CR, the situation of the point V and the path of the spectator may be found as in the note § page

as before so as to make the transverse distance of 60°, 60°, on the chords, equal to CB, and take the chord of the complement of the latitude of the place, which set from W on each side, to D and *d*. With the same opening of the sector measure the chord of the star's declination, which set on the circle ARB from the point D on each side to E and F, and from *d* on each side to *e* and *f*. Draw the dotted lines F*f*, D*d*, E*e*, cutting CW in *l*, *q*, *n*. Bisect *l n* in *r*, and erect the line *t r u* perpendicular to CW, and make *r t*, *r u* each equal to *q*D. Open the sector to make the transverse distance 90°, 90°, on the sines equal to *r t*, and on each side of *r* mark on the line *t r u* the sines of 15°, 30°, 45°, 60°, 75°, (equal to 1h. 2h. 3h. 4h. 5h. respectively) to that radius, and mark the points with those degrees as in the figure; through these points draw the dotted lines parallel to *ln* as in the figure. Open the sector so that the radius *r l* may correspond to the transverse distance 90°, 90° on the sines, and measure the complements of the former degrees as transverse distances on the sines, viz. 75°, 60°, 45°, 30°, 15°, and set them on the above dotted lines, on each side of the points 15°, 30°, &c. respectively above and below the line *t r u*. A regular curve *n t l u n* drawn through the extremities of these dotted lines will represent the path of the spectator in the given latitude. Subtract the sun's right ascension from the star's, (increasing the latter by 24 hours when necessary) the remainder will be the hour of the star's passing the meridian,* which is to be marked at the upper point *l* of the path if the star's declination is south, but at the lower point *n* if the declination is north. The other hours are to be marked from this point towards the left, by marking successively, at the points where the dotted lines meet the path, the hour of the star's passing the meridian increased by 1h. 2h. 3h. &c. completely round the curve, observing to reject 24 hours when the sum exceeds 24h. In the present example the star's declination is south, consequently the upper point *l* of the path is taken for the hour of passing the meridian 19h. 54′. The extremities of the dotted lines to the left being marked successively 20h. 54′, 21h. 54′, 22h. 54′, 23h. 54′, 0h. 54′, &c. The path touches the circle ARB in two points, representing the points of rising and setting of the star, which in the present figure are 14h. 9′ and 1h. 39′. These points divide the path into two parts of which one represents the path while the star is above the horizon, the other when below, as is evident from the hours marked on the curve. The half hours or any other intermediate time may be marked in a similar manner. Thus for the time 4h. 24′ which is 3h. 30′ or 52° 30′ from the time 7h. 54′ marked at the point *n*. Set the sine of 52°½ to the radius *r t* from *r* to *h* on the line *rt*, and erect the perpendicular *hi*, equal to the sine of 37°½ (which is the complement of 52°½) to the radius *rn*, and the point *i* will represent the place of the spectator at the proposed time. In this way the halves and quarters of hours may be marked on those parts of the path where necessary. The smaller subdivisions may generally be obtained to a sufficient degree of exactness by dividing the quarters of hours into equal parts.

Take from the scale of equal parts an extent equal to the semi-diameter of the moon, and beginning at the line NL towards N, find by trials the point *p′* of the moon's path and the point Z′ of the path of the spectator, marked with the same time and at that distance apart. That time will be the beginning of the occultation or immersion at the proposed place. Proceed in the same way towards the point L, and find the points *p*, *Z*, at the same distance apart, the corresponding time will be the end of the occultation or emersion. About the points *p′*, *p*, as centres with a radius equal to the moon's semi-diameter describe the small circles meeting the paths of the spectator in the points *Z′*, *Z*. These circles will represent the moon's disc; the points *Z′*, *Z*, the places of the star, and the lines CZ′, CZ, the vertical circles passing through the star at the times of immersion and emersion respectively. To render this part of the scheme more distinct to the eye, it is drawn separately in Fig. 9, Plate XII.; in which the point C, *p′*, Z′, are similarly situated to the corresponding points of Fig. 8, marked with the same letters. Through *p′* draw the line *a′ p c′* parallel to CZ′, to meet the moon's disc in *a′*, *c′*. Then the circle *a′* Z′ *c′* being held between the eye of the observer and the sun, the engraved or marked side of the figure towards the eye, and the line CZ′ (or *a′ p′ c′*) in a vertical position with the point Z′ above C, will represent the appearance of the moon and star as viewed by the naked eye, *c′* will represent the upper part of the moon, *a′* the lower part, and Z′ the point of contact. The contrary will be observed if the object be viewed by an inverting telescope. It will generally be conducive to the accuracy of an observation to estimate in this manner the point of emersion, so as to keep that point of the moon's limb in the field of view of the telescope, and the eye directed towards that point of the limb, so as to perceive the star at the first instant of its appearance.—The situation of the point of emersion with respect to the horns ρ, θ, of the moon may also be made use of for this purpose. The line $\rho\ p\ \theta$ connecting the moon's

* Or rather the horary distance of the ☉ and ✱ at the time of the ecliptic conjunction of the moon and star.

of the eclipse. If great accuracy is required the operation may be repeated with this approximate time, combining this result with one of the former suppositions, and thus the operation may be repeated till the apparent distance of the centres at the assumed time is found to be exactly equal to the sum of the corrected semi-diameters.

Remark. This rule, with some modification, will answer for calculating the time of an occultation of a fixed star or planet by the moon. In this case the star's longitude is to be found in Table XXXVII. and corrected for the equation Tables XL. XLI. (or the planet's longitude is to be taken from the Nautical Almanac) the difference between this and the moon's apparent longitude corresponding to the assumed time being found, its prop. log. is to be added to the log. secant of the moon's apparent latitude, and the sum is to be used in finding the distance of the centres instead of the prop. log. of the diff. long. of the sun and moon, with the index increased by 10. The latitude of the star is to be found by Tables XXXVII. and XLI. or the planet's latitude by the Nautical Almanac, and added to the latitude of the moon, if of a different name, otherwise their difference is to be taken and made use of, instead of the moon's latitude in the above rule. Lastly, instead of the sum of the semi-diameters, the semi-diameter of the moon is to be made use of. When very great accuracy is required, in calculating an occultation of a planet by the moon, the difference of the parallaxes of the moon and planet decreased by the correction of Parallax Table XXXVIII. is to be made use of as the reduced parallax, in finding the parallaxes in longitude and latitude. When the apparent distance of the centres of the moon and planet is equal to the sum of their semi-diameters their limbs will just appear to touch each other, and when that distance is equal to the difference of the semi-diameters the planet will be wholly covered by the moon.

EXAMPLE.

Required the time of the beginning of the solar eclipse of June, 1806, at Salem, supposing the errors of the moon's longitude and latitude in the Nautical Almanac to be unknown.

To abridge the present calculation, suppose the beginning of the eclipse to be June 15d. 22h. 6' 18".1 app. time, the elements corresponding to which have been calculated in Problem VI.; namely, ☽'s apparent longitude 84° 8' 50".3, ☽'s apparent latitude, 1' 55".8 N. these being corrected for the errors of the tables, 58".5 and 11".4, hence the uncorrected values are 84° 9' 48".8, and 2' 7".2 N. The difference between this app. long. of the moon and the sun's longitude 84° 41' 3".4, is 31' 14".6.

Diff. long.	31' 14".6	P. L.	10.7605		0.7605
☽ App. Lat.	2 7.2	P. L.	1.9259		
		Tan.	8.8346 –	Corresponding co-sine	9.9990
		App. Dis. ⊙ ☽	31' 19" 0	P. L.	.7595

This apparent distance differs 1' 4".5 from the sum of the semi-diameters 32' 23".5. It is therefore necessary to make a second supposition, as for example ten minutes later, or at 22h. 16' 18".1, with this time the elements are to be again calculated as in Problem VI. namely, ☽'s app. long. uncorrected 84° 14' 7".1, ⊙'s long. 84° 41' 27".2, their difference 27' 10".1, ☽'s app. lat. uncorrected for error of tables 1' 58".8 N.

Diff. long.	27.10".1	P. L.	10.8212		0.8212
☽ App. Lat.	1.58.8	P. L.	1.9586		
		Tang.	8.8626	Corresp. co-sine	9.9933
Second App. Dist. ⊙ ☽			27. 14".7	P. L.	.8200
First App. Dist. ⊙ ☽			31. 19 0		
Diff. 1st. dist.	Difference		4 1 3	P. L. Ar. co.	8.3515
	& Semi-diam.		1. 4 5	P. L.	2.2238
	Interval		10. 0.	P. L.	1.2553
	Correction		2. 38.	P. L.	1.8336
First supposed time			15d. 22h 6. 18.1		
Approximate time			15 22. 3. 40.1		

If this approximate time had differed very much from the assumed times, it would be necessary to repeat the operation till the last assumed and calculated times agree.

PROBLEM XIV.

Given the moon's true longitude to find the apparent time at Greenwich.

RULE.

1. Take from the Nautical Almanac the two longitudes immediately preceding

EXAMPLE.

Suppose that on the 7th. January, 1808, sea account, at 6h. 57m. P. M. in the longitude of W. by account, the observed distance of the farthest limb of the Moon from the star Aldebara 39° 7' 4", the observed altitude of the star 43° 18', and the observed altitude of the Moon's lowe 52° 52'. Required the true longitude, without using the distances marked in the Nautical Alm upon the supposition that they were not given in it.

In this case the supposed time at Greenwich was Jan. 6d. 14h. 37m. ☽'s horiz. par. 54' 35". S. D. 15' 5". Apparent distance of centres ☽ ✱ 38° 51' 59", whence (by the rule page 163 correct distance is 38° 47' 26". The Moon's latitude deduced from the N. Almanac by Probl is 2° 37' 36" N. The star's longitude and latitude is found by Tables XXXVII. XL. XLI. m use of the longitude of the Moon's node 7s. 28° 15', and the Sun's longitude 9° 15' 42", as giv the N. A.

Table XXXVII. ✱ Long. Jan. 6, 1808,	67°.6'.21".5	✱ Latitude	5°.28'.49".6 S.
Table XLI. ✱ Aberration	+ 15. 7	Aberration	+ 1. 2
Table XL. Equat. Equinox	+ 15. 2	✱ App. Lat.	5 28. 51 S.
✱ Apparent longitude	67. 6. 52		
Correct Distance	38 47. 26		
☽ Latitude	2.37. 36 N.	Sec. 0.00046	
✱ Latitude	5.28. 51 S.	Sec. 0.00199	
Sum	46.53. 53		
Half sum	23.26. 56	Sine* 9.59981	
Diff. ½ sum and dist.	15 20. 30	Sine* 9.42255	
		19.02481	
½ Diff. of Long.	18 59. 21	Sine* 9.51240	
Diff. of Long.	37 58. 42	☽ West of ✱	
✱'s Longitude	67. 6. 52		
☽ Longitude	29. 8. 10		
☽ Long. Jan. 6d. 12h.	27 49. 6		
Difference	1.19. 4=4744'		

			Diff. ° ' "		2 Diff.
☽ Longitude, Jan.	6d. 0h.	21. 53. 10			
	6. 12	27. 49. 6	A 5 55 56		+1°.30"
	7. 0	33 46. 32	5 57 26		+2. 8
	7. 12	39. 46. 6	5 59.34	Mean B.	+1. 49

Constant log.	4 63548			4.63548
A=5°.57'.26"=21446" log. co.	5 66865			5 66865
1. 19. 4 = 4744" log.	3.67614	Eq. Tab. XLV.+9".4	Log.	0.97313
Approx. time 2h. 39' 16"=9556" Log.	3 98027	Correction + 19"	Log.	1.27726
Correction + 19				

Time T	2. 39. 35	Hence time at Greenwich	14h. 39' 35"
		App. time at ship	6. 37. 0
		Longitude	8. 2. 35=120°.39'¾ W

PROBLEM XVI.

Given the intervals of time between the passages of the moon's limb and a fixed over two different meridians, to find the difference of longitude of the two ridians.

In making these observations it is usual to note the times of transit by a cloc gulated to siderial time, being the most convenient for calculation. If the inter are given in *mean* solar time, they may be reduced to siderial, by adding a pro tional part of the daily difference 3' 56".6. Thus if the interval was 6 hours n time, the correction would be found by saying as 24h. : 6h. : : 3'.56".6 : 59".1, w added to 6h. gives the interval in siderial time 6h. 0' 59".1. In the following ru is supposed that the intervals are given in siderial time. The constant logar 4.63667 made use of in the rule is the logarithm of 43318 seconds, the number o conds siderial time in half a *mean* solar day. In strictness this quantity ought t equal to the logarithm of the number of seconds siderial time in 12 hours *appa* time, which may differ 15 seconds from 43318" on account of the daily variatio the equation of time. The correction arising from this source is very small and in general be neglected, though it can be allowed for in a very simple manner, s the logarithm varies an unit in the fifth decimal place for 1" of time. Hence the rection of the logarithm is equal to half the daily variation of the equation of tim

* Use co sine if the latitudes are of the same name.

seconds, given in the Nautical Almanac, to be *added* to 4.63667 when the equation of time is marked *add* and is increasing, or *sub.* and decreasing; otherwise *subtracted.* Thus if the observation was made July 4, 1808, the equation of time is marked add, and is increasing daily 10″.5. half of which or 5 is the correction to be added to 4.63667 to obtain the logarithm 4.63672, to be made use of July 4, 1808.

RULE.

If the moon be observed at both places on the same side of the star, take the difference of the observed intervals, otherwise the sum, which reduce to seconds of siderial time, and find the corresponding logarithm; to which add the arith. comp. log. of the variation of the moon's right ascension* in 12 hours in seconds, and the log. 4.63667 (corrected for the variation of the equation of time, as directed above, when very great accuracy is necessary.) The sum, rejecting 10 in the index, will be the log. of a number of seconds, from which subtract the above difference of intervals, the remainder will be the longitude in time.

The *western* place of observation corresponds to the *greater* interval if the star is *west* of the moon, the *lesser* if *east.* If the moon be observed on opposite sides of the star, the western place will be where the star is to the westward of the moon.

EXAMPLE.

Suppose that on the 4th. of July, 1808, the interval in siderial time between the transit of the moon's western limb and Antares, observed at Greenwich, was 22′ 6″; and the interval at a second place was 20′ 3″; the increase of the moon's right ascension in 12 hours (corresponding to the middle time of the moon's transit by the meridians of the two places reduced to Greenwich time, 9h. 26′) being by Prob. II. Ex. III. 30′ 22″.1 the star being to the eastward of the moon. Required the longitude of the second place of observation?

Interval at Greenwich	22′. 6″ Sid. time.		
.... at second place	20. 3		
Diff. of intervals	2. 3 = 123″	log.	2.08991
Var. ☽ R. A. in 12h. 30′ 22″.1.	in time=1822″.1	log. co.	6.73943
Constant log. Corrected as above.			4.63672
	2925″	log.	3.46606
Subtract diff. intervals	123		
Remains long. in time	2802=46′ 42″ W. from Greenwich.		

This method of determining the longitude admits of a very great degree of accuracy on account of the frequent opportunities of observation. Other methods of finding the longitude depending on the same principles have been proposed. One consists in observing the apparent time of the moon's passing the meridian, and comparing it with the time of passing observed at Greenwich, or deduced from the Nautical Almanac, and taking the difference of these times, and saying, as the daily difference of the moon's passing the meridian (deduced from the Nautical Almanac for the time of observation) is to 360°, so is the above difference to the longitude of the place. Another method consists in deducing the longitude from the change of declination of the moon, obtained from her observed altitude when on the meridian, and the known latitude of the place of observation, by a method somewhat similar to the preceding; but neither of these methods is susceptible of the same degree of accuracy as that in the above Problem.

It is not absolutely necessary that the same star should be made use of at both places: for if two stars be observed, whose difference of right ascension is accurately known, that difference will be equal to the interval of passing of the two stars to the meridian in siderial time, and by applying this to one of the intervals, the observations may be reduced to be the same as if one star only had been used.

PROBLEM XVII.

Given the longitudes of the sun and moon, and the moon's latitude, to find their distance.

RULE.—Find the difference of the two longitudes, and to its log. co-sine add the log. co-sine of the moon's latitude, the sum, rejecting 10 in the index, will be the log. co-sine of the sought distance, of the *same affection*† as the difference of longitude.

EXAMPLE.

July 16, 1808, at noon at Greenwich, by the Nautical Almanac, the sun's longitude was 3s. 23° 40′ 24″. the moon's longitude 1s. 3° 14′ 1″, and her latitude 1° 24′ 23″ N. Required their distance?

* In general it will be exact enough to take the difference between the moon's R. A. marked in the Nautical Almanac for the nearest noon and midnight, but when very great accuracy is required, it may be found as in Prob. II. Ex. III. for the middle time between the two transits of the moon by the meridians of the two places; reduced to Greenwich time by adding the longitude if west, subtracting if east.

† Two arches or angles are said to be of the *same affection* when they are *both greater or both less* than 90°, but of *different affection* when *one is greater and the other less than* 90°.

form, and the first varies but little from that made use of by Napier, so that it is extremely easy to remember them. The case not included in these rules may be solved by one of the formulas of case 5, or 6, which may be committed to memory with little trouble. To illustrate these rules the following examples are given, which include all the cases of Oblique Spheric Trigonometry.

CASE I, PLATE XII. Fig. 3, 4, 5, 14.

Given AB, AC, and the opposite angle C, to find BC and the angles A, B.

In the right-angled spheric triangle APC are given AC and C, and by marking it as in fig. 2, CP may be found by the rules *sine mid.=tang. adj.* which gives sine (co. C)=tang. CP×tang. (co. AC,) or tang. CP=co-s. C×tang. AC.‡ Then in the triangles ABP, ACP are given AB, AC and CP to find BP. If to these is joined the perpendicular AP it will be found that in the triangle ACP the complement of AC is the middle part, (as in Fig. 3), and CP an opposite part. The triangle ABP is to be marked in a similar manner. Then the rule *sine mid. ∝ co-s. opp.* gives sine (co. AC) : co-s. CP : : sine (co. AB) : co-s. BP, and BC=B $P \underset{\backsim}{+} CP$. By marking the segments as in Fig. 4, the rule *sine mid. ∝ tang. adj.* gives sine CP : tang. (co. C.) : : sine BP : tang. (co. B.) Having found BC, the angle A may be found by the rule *sine side. ∝ sine opp. angle* which gives sine AB : sine C : : sine BC : sine A.

Otherwise. If the side BC is not required, the angles A, B, may be found in the following manner. The rule *sine mid.=tang. adj.* gives by marking as in Fig. 1. sine (co. AC)=tang. (co. C)×tang. (co. CAP) or cot. CAP.=co-s. AC×tang. C, and by marking as in Fig. 5, the rule (sine mid. ∝ tang. adj. or) *tang. adj. ∝ sine mid.* gives tang. (co. AC) : sine (co. CAP) : : tang. (co. AB) : sine (co. BAP,) then $A=BAP \underset{\backsim}{+} CAP$. By marking the segments as in Fig. 14, the rule (sine mid. ∝ co-s. opp. or) *co-s. opp. ∝ sin. mid.* gives co-s. (co. CAP) : sine (co. C) : : co-s. (co. BAP) : sine (co. B) or sine CAP : co-s. C : : sine BAP : co-s. B. Having A, C, and AB, BC may be found by the rule *sine side ∝ sine opp. angle,* which gives sine C : sine AB : : sine A : sine BC.

CASE II. Fig. 3, 4. Plate XII.

Given AC, BC and the included angle C, to find AB, and the angles A, B.

The rule *sine mid.=tang. adj.* gives as in Case I. tang. CP=co-s. C×tang. AC, then $BP=BC \underset{\backsim}{+} CP$ and the rule *co-s. opp. ∝ sine mid.* gives by marking as in Fig. 3. co-s. CP : sine (co. AC) : : co-s. BP : sine (co. AB,) and by marking as in Fig. 4. the rule *sine mid. ∝ tang. adj.* gives sine CP : tang. (co. C) : : sine BP : tang. (co. B.) Having found AB we may find A, by the rule *sine side ∝ sine opp. angle,* which gives sine AB : sine C : : sine BC : sine A.

If the angle A had been required and not B, it would have been shorter to let the perpendicular fall upon the point B, by which means the required angle A would not be divided into segments. In this case the side AB and the angle A might be found in a similar manner to that by which AB and B are found above.

CASE III. Fig. 3, 4, 5, 14. Plate XII.

Given the angles B, C, and the opposite side AC to find BC, AB, and the angle A.

The rule *sine midd. ∝ tang. adj.* gives as in Case I. tang. CP=co-s. C × tang. AC. Then the rule *tang. adj. ∝ sine mid.* gives, by marking as in Fig. 4. tang. (co. C.) : sine CP : : tang. (co. B) : sine B P, then $BC=CP \underset{\backsim}{+} BP$. Again, the rule *co-s. opp. ∝ sine mid.* gives by marking as in Fig. 3, co-s. C P : sine (co. AC) : : co-s. B P : sine (co. AB.) Having found BC, the rule *sine side ∝ sine opp. angle* gives sine AC : sine B : : sine BC : sine A.

Otherwise—The rule *sine mid.=tang. adj.* gives as in Case I. cot. CAP=co-s. AC×tang. C, and the rule *sine mid. ∝ co-s. opp.* gives by marking as in Fig. 14, sine (co. C) : co-s. (co. CAP) : : sine (co. B) : co-s. (co. BAP) or co-s. C : sine CAP. : : co-s. B : sine BAP, and $A=CAP \underset{\backsim}{+} BAP$. Then the rule *sine mid. ∝ tang. adj.* gives by marking as in Fig. 5. sine (co. CAP) : tang. (co. AC) : : sine (co. BAP) : tang. (co. A B.) Having found A the rule, *sine side ∝ sine opp. angle* gives sine B : sine AC : : sine A : sine BC.

CASE IV. Fig. 5, 14. Plate XII.

Given the angles A, C and the included side AC, to find AB, BC and the angle B.

The rule *sine mid.=tang. adj.* gives as in Case I. cot. CAP=co-s. AC×tang. C, and $BAP=A \underset{\backsim}{+} CAP$. The rule *sine mid. ∝ tang. adj.* gives by marking as in

‡ *In putting this or any similar expression in logarithms the radius must be neglected in the sum of the two logarithms of the second number.*

55.50 25

52,45